PROPERTY CONDITION ASSESSMENT
OF
WORLD TRADE CENTER PORTFOLIO

ONE WORLD TRADE CENTER

Located In

NEW YORK, NEW YORK

Prepared For

THE PORT AUTHORITY OF NY & NJ
WORLD TRADE CENTER COMPLEX
NEW YORK, NEW YORK 10048

Prepared By

MERRITT & HARRIS, INC.
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FINAL DRAFT

Property #1

Merritt & Harris, Inc. Project Number 20-251E

CD File SK012487

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20-251E

December 6, 2000

Mr. Jeffrey S. Green
General Counsel
The Port Authority of NY & NJ
1 World Trade Center
New York, New York 10048

**Re: Due Diligence Physical Condition Survey
World Trade Center
New York, New York**

Dear Mr. Green:

Enclosed are 7 copies of our report of the conditions observed during our site visits to the referenced property between September 13 and October 31, 2000. For this report, I served as the Project Coordinator, with Peter J. Brady, P.E., as Project Manager and Structural Engineer, and Jack M. Kagan and Joseph Marciano, P.E., as Mechanical/Electrical Engineers.

As previously agreed, Merritt & Harris, Inc. has divided the report into 7 segments as follows:

1. One World Trade Center (Tower A)
2. Two World Trade Center (Tower B)
3. Retail Mall and Plaza
4. Four World Trade Center (Southeast Plaza Building)
5. Five World Trade Center (Northeast Plaza Building)
6. Central Services
7. Subgrade

For convenience, identical copies of Sections I - IV (I - Identification, II - Objective, III - Procedures and Limitations, and IV - Executive Summary) have been included with each report so they can stand independently, if required to do so.

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Thank you for selecting Merritt & Harris, Inc. as your consultant on this project. If you have any questions, please call me.

Very truly yours,

MERRITT & HARRIS, INC.

Robert G. Weiland, R.A.
Vice President & Principal

RGW:rw
Enclosure

cc: Thomas C. Richard
Peter Brady
Jack Kagan
Joseph Marciano

REPORT OF
DUE DILIGENCE PHYSICAL CONDITION SURVEY
WORLD TRADE CENTER

Located At

WORLD TRADE CENTER COMPLEX
NEW YORK, NEW YORK

Prepared For

THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY
1 WORLD TRADE CENTER
NEW YORK, NEW YORK 10048

Prepared By

MERRITT & HARRIS, INC.
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TABLE OF CONTENTS

SECTION I - IDENTIFICATION

Project Name:	World Trade Center
Location:	One - Five World Trade Center New York, New York 10048
Report Prepared For:	Mr. Jeffrey S. Green, General Counsel The Port Authority of NY & NJ 1 World Trade Center New York, New York 10048
Site Visits and Report By:	Thomas C. Richard, AIA *President and CEO* Merritt & Harris, Inc.
	Robert G. Weiland, R.A. *Project Coordinator* Merritt & Harris, Inc.
	Peter J. Brady, P.E. *Project Manager and Structural Engineer* Merritt & Harris, Inc.
	Jack M. Kagan *Mechanical Engineer* Merritt & Harris, Inc.
	Joseph Marciano, P.E. *Mechanical Engineer* Merritt & Harris, Inc.
	Vish Shetty *Elevator Field Engineer* BOCA Group International
	John Beamish *Elevator Field Engineer* BOCA Group International
	Robert Wernon *Elevator Field Engineer* BOCA Group International
	William G. Young, P.E. *Facade Consultant* Heitmann & Associates
	Wayne Crandlemere *Environmental Consultant* Crandlemere & Associates

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Dates of Site Visits: September 13 - October 31, 2000

SECTION II - OBJECTIVE

The purpose of the on-site evaluation and document review is to assess the general physical condition of the property as it currently exists. This report provides a narrative and photographic description of the buildings, as well as a listing of any deficiencies that were noted during our site visit.

The report has been divided as follows into seven component sections for ease of handling:

1. One World Trade Center (Tower A)
2. Two World Trade Center (Tower B)
3. Retail Mall and Plaza
4. Four World Trade Center (Southeast Plaza Building)
5. Five World Trade Center (Northeast Plaza Building)
6. Central Services
7. Subgrade

Each of the volumes contains descriptions of the component, recommendations for items requiring action, and photographs and supporting documentation specific to each component of the project. An overall Executive Summary, identical for all volumes, has been reproduced and included in each of the volumes for convenience. Shared site feature and service elements are described and discussed within the Executive Summary section. Due to the nature of the project, some of the construction elements may be shared or physically interconnected among 2 or more of the project components. As a result there may be some redundancy noted in the report in order to indicate the support of 2 or more project components by these systems.

The Recommendations section for each volume is a listing of items that will require action within the next 10-year period. Immediate (0-1 Year) issues are deficiencies which are in violation of codes, which pose a danger to public safety, or which, if left uncorrected, will lead to further deterioration of the property or significantly impact marketability or habitability. Issues that will require addressing during the second to the tenth years are divided into 2 categories, Future (1-5 Years) and Future (6-10 Years). These categories represent work not required by agencies or codes, but which, in our opinion, are issues that should be attended to in the context of the prudent management of the property.

ADA compliance work is considered to be mandatory and is listed separately.

SECTION III - PROCEDURES AND LIMITATIONS

To adequately determine the present conditions at the World Trade Center (WTC), Merritt & Harris, Inc. performed on-site observations between September 13 and October 31, 2000. Mr. Leandro Zucchi, Assistant General Manager, Building Services Management of the Port Authority, acted as the Project Coordinator, arranging security clearances, providing knowledgeable escorts for the various components of the project, and facilitating review of available documentation. Over a period of several weeks, our field personnel physically observed the buildings, reviewed documentation, and interviewed Port Authority personnel regarding building conditions, operations and maintenance procedures, and capital projects.

Because of the physical complexity of so large a project, the separation of individual systems into definable areas for inclusion in the reports of the various buildings was not easily achieved. While we have attempted, with the assistance of Port Authority personnel, to assign systems to their associated buildings, the assignments are based on our opinion, with input from the Port Authority, of where the systems logically fall. As the division of buildings and systems into individual entities was never planned or previously assigned, any attempt to separate the buildings and systems for individual transactions should be carefully studied and documented. As we understand from the Port Authority that the WTC transaction will be accomplished by treating the complex as a single entity, the division of buildings and systems in this report has been done to clarify the reporting and simplify the task of reading so large a document.

Merritt & Harris, Inc. selectively reviewed documentation available in the WTC Data Center, located on the 3rd floor of 5 WTC. Merritt & Harris, Inc. focused on those items relating to the physical buildings, and did not review such items as financial reports and leasing documentation. The primary documentation used by Merritt & Harris, Inc. was from the following categories in the Checklist Items:

A. General Property Information
D. Environmental Information (Note that this information was not in the Data Room, but was provided to Mr. Crandlemere in the Port Authority office of Mr. Phil Taylor)
E. Operating and Maintenance Manuals
I. Structural Integrity Inspection Reports
J. Facades
K. Mechanical Reports/Information
L. Vertical Transportation Profile & Inspection Reports
M. Electrical Reports
N. Blast Related Reports/Information
O. Life Safety Code Analysis

Attachment 3 is the Due Diligence Checklist, or listing of available documents as of October 31, 2000.

In addition, a set of original construction documents was available on CD ROM format. A selective review of these drawings was done to familiarize our staff with the basic building layouts, material selections, and design criteria. Due to the volume of documentation available, an exhaustive plan, specification and code review of this property was not performed. Merritt & Harris, Inc. accessed these documents in an attempt to clarify issues raised by observations in the field or to further research references to building components mentioned in the reports by other consultants available in the Data Room.

Our observations were limited to those portions of the project that were visible during the walk-through. In many areas, building finishes concealed structural components from view. Merritt & Harris, Inc. neither took material samples nor performed tests on the building materials or systems. Our investigation of the building facades was performed from ground level and from the roofs.

Some equipment observed was not operating during our visit due to seasonal requirements. No attempt was made to operate the equipment as the facility was occupied and appropriate climate control was required. In the case of idle machinery or equipment, our opinions were formed by interviewing available personnel and reviewing any maintenance records presented to us. In order to be as fully apprised as possible of the operating condition of the major pieces of machinery, a Mechanical Contractor should be retained to start the equipment and witness its operation over a period of time.

While the Port Authority does have a basic emergency plan for dealing with flooding on the property, there is no existing control method to prevent catastrophic flooding of the subgrade levels up to level B-2 due to the total flooding of the PATH tubes. Pockets for control doors were built into the perimeter slurry wall, but doors were never installed, as this method of protecting the building would pose a life-safety threat to trains and passengers in the PATH tubes. The complexity of this problem and the specific expertise needed to address the issues is beyond the scope of competence of Merritt & Harris, Inc. and has not been addressed in this report.

It is not the intent of Merritt & Harris, Inc. to assume any part of the design responsibility, but rather to report our findings to our Client to whom this report is addressed. It is further understood that as building maintenance is ongoing, some areas of concern noted in this report may have been addressed subsequent to our site visit and may no longer be applicable.

The square footage areas used in the following sections are as provided in the J.P. Morgan Offering Memorandum, dated June 21, 2000 (the Offering Memorandum), and in the J.P. Morgan Property Book, dated June 21, 2000 (the Property Book). Independent field measurement of buildings and/or tenant spaces or plan takeoffs is outside the scope of this assignment.

On behalf of the Client, Merritt & Harris, Inc. engaged an independent consultant to conduct a **Phase I Environmental Site Assessment and Asbestos Audit** at the site in conjunction with the due diligence. The survey was conducted by members of the staff of R.W. Crandlemere and Associates, Inc. (Crandlemere) of Weymouth, Massachusetts. The survey included visual observations of the site and buildings, and the accumulation and review of available documentation pertaining to asbestos, hazardous waste, and electromagnetic radiation generated by the roof-mounted communications transmission equipment. Crandlemere took no samples and made no physical tests. The results of the survey and any associated recommendations are contained as attachments to this report. Merritt & Harris, Inc. assumes no liability regarding asbestos audits, hazardous or toxic material monitoring, surveying, or reporting and cannot be responsible for the

work or opinions of other independent consultants engaged to do so. Merritt & Harris, Inc. reviewed the subconsultant's report and extracted summary information for inclusion within our narratives for the convenience of the reader. The environmental subconsultant's reports are provided as attachments to the individual building reports and in their entirety in **Attachment 6** (separate binder) of this portion of the report.

On behalf of the Client, Merritt & Harris, Inc. engaged an independent consultant to conduct an **Elevator Review** at the site in conjunction with the due diligence. The survey was conducted by members of the staff of The BOCA Group International (BOCA) of New York, New York. The survey initially included visual observations of a pre-selected random sampling of 21 elevator and escalator devices at the buildings, and the review of available documentation pertaining to elevator maintenance and modernization programs. The sample elevators selected for observation were chosen to provide a representative specimen from each building and zone and included modernized, partially modernized, and original elevators. Following the initial sampling, BOCA further reviewed and observed additional devices based on callback data provided by the Vertical Transportation Department and on reports prepared by the Port Authority's independent elevator consultant. The reader should note that a bank of elevators (18-23B) was involved in a recent run-by incident. These elevators were not observed and have been excluded from our review to avoid interference with an ongoing legal investigation. The tenant-owned and operated elevators and escalators were not observed and do not form part of this report. Merritt & Harris, Inc. reviewed the subconsultant's report and extracted summary information for inclusion within our narratives for the convenience of the reader. The subconsultant's reports are provided in their entirety as attachments to the individual building reports.

On behalf of the Client, Merritt & Harris, Inc. engaged an independent consultant to conduct a **Curtainwall Investigation** at the site in conjunction with the due diligence. The survey was conducted by members of the staff of Heitmann & Associates, Inc. (Heitmann) of New York, New York. The survey included visual observations of the facades from interior spaces, grade level, and roofs of the buildings, and reviews of available documentation pertaining to the exterior wall maintenance and inspection programs. Heitmann personnel did not ride or descend on any scaffolding or rigging to observe the exterior walls. Merritt & Harris, Inc. reviewed the subconsultant's report and extracted summary information for inclusion within our

narratives for the convenience of the reader. The subconsultant's reports are provided in their entirety as attachments to the individual building reports.

The Merritt & Harris, Inc. assignment included a general review of the building's compliance with Title III of the Americans with Disabilities Act (ADA). Items of nonconformance are cited without regard for whether or not they are, by ADA definition, readily achievable. Factors to be considered in determining whether or not an action is readily achievable include the nature and the cost of the action needed, the overall financial resources of the operation, and the number of persons employed at the site. The decision as to which actions are to be undertaken rests, therefore, with the building ownership in consultation with its accountants, lawyers, and architects. Our general observation of the property's ADA status and related comments is not intended, and should not be construed, to replace a full ADA audit and report.

As stated in the Offering Memorandum, "The Port Authority is a municipal corporate instrumentality and political subdivision of the States of New York and New Jersey which provides transportation, terminal, and other facilities of commerce within the Port District. As such, in connection with the Transaction, the PA will continue to maintain exclusive jurisdiction with respect to certain administrative and governmental matters involving the Complex, including compliance with building, environmental, fire and health codes." The New York City Department of Buildings has indicated to our personnel that they do not maintain any records of violations for this property. A request for a Property Profile Overview for this block and lot number yields no records. The Fire Department provides normal fire fighting and a life safety service to the facility. A Memorandum of Understanding exists between the Port Authority and the Fire Department in which the Fire Department performs regular inspections and directly notifies the Port Authority Fire and Life Safety group of deficiencies to be corrected. Under a protocol with the New York City Fire Department, Port Authority Police personnel investigate certain fire alarms at the World Trade Center rather than transmitting such alarms to the New York City Fire Department.

The Merritt & Harris, Inc. report is intended for the use of the General Counsel of the Port Authority.

SECTION IV - EXECUTIVE SUMMARY

Project Scope

Property Components

The subject property consists of a 6-building complex (4 office buildings, a separate government office building, and a hotel) constructed on top of a 2-level retail mall and a 6-level Subgrade development. The Subgrade contains an underground parking garage, loading docks, storage facilities, and central mechanical and electrical services for the overall property. The Hotel, the New York Marriott World Trade Center (3 WTC), and the governmental office building, the Customs House (6 WTC), are not included in the transaction and, therefore, are not included in the scope of the Merritt & Harris, Inc. assignment or this report. The complex is located in the Financial District of downtown Manhattan, New York City and was completed in phases between 1970 and 1977. The following area summary information is taken from the Offering Memorandum and Property Book.

Building	Year Built	Gross Sq. Ft.	Remeasured Sq. Ft.	Rent Roll Sq. Ft.
One	1970	4,761,416	4,468,634	4,358,604
Two	1972	4,761,416	4,470,598	4,173,612
Four	1977	462,738	505,670	470,978
Five	1975	581,238	632,782	612,958
Subtotal Offices		**10,566,808**	**10,077,684**	**9,616,152**
Retail	1970	614,901	440,327	427,448
Total		**11,181,709**	**10,518,011**	**10,043,600**

Common Site Features The following site features are common to all of the 7 Property Components:

Legal Description Block 58, Lot 1

Zoning District C6-4, C5-3

Easements and/or Encroachments A property survey is reportedly being prepared, but was not yet completed at the time of this assignment. Our investigation of other documentation and interview of various Port Authority personnel during this assignment have yielded certain information about possible easements or encroachments.

The site is shared by 6 buildings and the retail mall. The Marriott Hotel (WTC 3) and the Customs House (WTC 6) are outside the scope of this transaction; however, there are known interconnections of services and access to shared facilities.

Conventional utility company easements are assumed. In addition there are public rights-of-way for the New York City Transit Authority subways and the PATH rail system throughout the complex.

Interconnecting bridges to three adjacent properties (130 Liberty Street, 2 World Financial Center, and 7 WTC) are reportedly the responsibility of the adjacent owners. There are, however, certain physical connections such as foundations, and service connections such as electrical power services that may be subject to easement or covenant agreements.

The WTC complex also includes a remote river water pumping station, west of West Street in Battery Park City. This station is located under the Plaza near the marina at the Hudson River and Liberty Place. The interconnecting river water loop piping runs underground from the pump station, east along Liberty Place, then north along the west side of West Street, and then eastward across West Street entering the complex at 1 WTC. There is also a river water return out-fall which occurs underground behind the sea wall near the adjacent 2 World Financial Center.

Size/Layout	The site is trapezoidal in shape and contains 15.65 acres. The site is bordered by Vesey Street on the north, Church Street on the east, Liberty Street on the south, and West Street on the west. The Marriott Hotel and the Customs House are excluded from the disposition; however, the land leased for those properties is included in the total site area noted.
Topography	The site slopes gradually downward from the east, where the street grade is roughly equal to Plaza Level, towards the west where the street grade is at Concourse level. The constructed Tobin Plaza, in the central area of the site, is accessed by gently sloped ramps up from Church Street, and by exterior stairways and escalators from the other streets.
Flood Plain	The bulk of the site towards the east side is located in Flood Zone C, an area of minimal flooding outside the 500 year flood plain as indicated on the National Flood Insurance Program Flood Insurance Rate Map, Community Panel Number 360497 0054B effective November 16, 1983. Two areas at the midpoint of the north and south boundaries are within Zone B, areas between the limits of the 100-year flood and 500-year flood, and the western edge of the site is within the 100-year flood zone. While the Port Authority does have a basic emergency plan for dealing with flooding on the property, there is no existing control method to prevent catastrophic flooding of the subgrade levels up to level B-2 due to the total flooding of the PATH tubes. Pockets for control doors were built into the perimeter slurry wall, but doors were never installed, as this method of protecting the building would pose a life-safety threat to trains and passengers in the PATH tubes.
Geological Hazards	The site is located in UBC Seismic Zone 2a, an area of minimal seismicity.
Service Utilities	A complete site survey is in the process of being compiled, but was not available at the time of this report. The information contained in this report is based upon a combination of directly observed utilities and information contained in other reports. In this way, the exact number and size of the utility services has not been included. Electric - Consolidated Edison (New York Power Authority) Steam - Consolidated Edison Gas - Consolidated Edison Water and Sewer - City of New York Various telecommunications carriers

Underground Irrigation System	None
Access	Pedestrian access is provided at grade on all four bounding streets of the complex and from the central Tobin Plaza. The project also has direct interior access to NYC subway systems (five interior access points to 3 separate subway lines) and the interstate PATH mass-transit systems. Vehicular access for automobiles is limited to pre-screened tenants on a rental basis, to selected Port Authority employees, and to contractors having an agreement with the Port Authority for parking privileges. There are 4 ramps for access to the automobile parking areas; 1 entrance and 1 exit ramp (Ramps B&C) on the north end of the property on West Street, an exit ramp (Ramp D) on the south end of the property on West Street, and an entrance ramp (Ramp H) on the west end of the property on Liberty Street. These ramps are protected by guard station checkpoints and Delta barriers, which are mechanically operated barriers, which swing up out of the pavement to physically block the ramp. Delivery access is by means of a ramp from Barclay Street, one block north. This ramp passes under an adjacent building, 7 WTC. It is protected by a security checkpoint.
Paving	Surrounding streets are paved with asphalt. Parking ramps are concrete.
Sidewalks	The sidewalks surrounding the complex are generally exposed aggregate concrete, with some areas of granite paving that have been installed to accent building entrances.
Curbing	Curbs at the roadways are steel.
Plaza Deck	The Plaza is a granite surfaced reinforced concrete deck with a bituminous waterproof membrane. Areas of the perimeter of the deck, particularly under the building overhangs of 4, 5, and 6 WTC remain the original concrete with exposed aggregate surface. Expansion joints occur at the perimeter of each of the Tower buildings, and along the east side of the Plaza at the high end of the Church Street entry stairway and ramps.
Deck Drainage	The Plaza generally pitches towards the central area near the fountain where the runoff is collected by a circular trench drain surrounding the recessed fountain area.

Landscaping

Sidewalk wells, with cast iron gratings, framed in red granite pavers are provided for street trees along the Liberty, Church and Vesey Street sidewalks. Raised planters with shrubs and annual flowers separate the central stairway from the 2 ramps at the Church Street entrance to Tobin Plaza. All other plantings are contained in monumental sized concrete planters that also serve as security barriers to prevent unauthorized vehicular access. Other street furniture includes concrete benches and concrete and stainless steel security barriers in sculptural shapes.

Site Lighting

City street lighting on perimeter sidewalks, newly installed site lighting from the roof line of 4 and 5 WTC, and pole-mounted, multiple-lamp fixtures on the Plaza.

Fencing

Some rollaway security gates are provided at the base of exterior stairways to prevent unauthorized after-hours entry.

Amenities/Special Features

The major site amenity is the central Austin Tobin Plaza, a public space enclosed by the 6 buildings that make up the complex. The Plaza focuses on a central fountain and sculpture, representing the sun and its outward flowing rays. The Plaza is the focus of formal and informal activity during the warm weather months, when outdoor music, street vendors, and seating for the Plaza Level restaurant tenants all contribute to the life of the space. A smaller "Memorial Fountain" commemorating those who lost their lives in the terrorist bombing, is located at the west side of the Plaza between 1 WTC and the Hotel building. The Plaza is reportedly closed down in the winter months to prevent potential injury to pedestrians by the possibility of ice falling from the Towers.

The asphalt-paved area to the east of the site has recently had benches and planters installed, adding more outdoor seating for public use. A covered performance stage was installed in this area during the past summer for the Plaza's summer music program. A temporary "Green Market" is also one of the seasonal features used to draw street traffic to the site. Some sections of this area have at times been used for special parking requirements.

Signage

There is a polished stainless steel monolith with a bronze plaque and a red numeral designation at the main entrance door for each of the buildings in the complex. Additional exterior signage is building installed.

Mall entrances are marked with back-painted signs on the glass transoms above the entrance doors. Retail tenants with exterior exposure have window-mounted signage. Major commercial office tenants have signage on some of the entrance door transoms. Awnings with Mall signage have recently been installed at Mall entrances.

Ancillary Structures

The river water pump station is located about one block west of the site at Liberty Place and the Hudson River. It is an underground structure beneath the pavement of Battery Park City Plaza. It is included in the Central Plant Report.

There are some minor kiosk installations for bus shelters, street vendors, and taxi cab dispatchers around the site.

Project Condition

The buildings were originally constructed of good quality materials. The overall present condition of the property is good. However, as with any large complex of this age, ongoing repair and maintenance should be expected to be required.

Site

Site improvements are adequate and appropriate for a project of this size and status. The majority of the Plaza, which serves as the roof for the retail mall, was resurfaced in red and gray granite during the Plaza rehabilitation of 1998-99. The fountain was rehabilitated and made fully operational. New benches and planters were installed. The membrane waterproofing beneath the old pavement was probed and found to be functioning well. In general, the concrete sidewalks around the site perimeter are sound without tripping hazards, but there has been spalling and cracking over the years that is beginning to lead to an unattractive appearance. A 1999 study of the sidewalk conditions was performed by M.E.D.D, a unit within the Port Authority Engineering Department. M.E.D.D. included several recommendations for upgrades; however, there has been no decision to proceed with any of the work at this time. Plaza areas outside of the new granite surface have varying degrees of deterioration. However, the repairs have not been implemented pending the coordination of pavement repairs with the possible extension of retail areas under the building overhangs of 4 and 5 WTC. Pavement replacement is in progress along the West Street side of the site adjacent to the Customs House as a separate project under the auspices of the U.S. General Services Administration.

Structural

The building structures appear to be in adequate overall condition. Major structural repairs following the 1993 bomb blast were successfully completed and signed-off by a Permit to Occupy or Use issued by the Port Authority Office of the Chief Engineer on October 10, 1997. The repairs appear to have been properly engineered and executed. Following the bombing incident, stringent security measures were implemented at the vehicular entrances to the Plaza and subgrade facilities.

In the buildings we observed only minor cracking in some slabs, partitions or in stairwells of the buildings. Some minor slab cracks have been noted which should be monitored by the PA's structural consultant. The slabs at the truck dock and delivery area on level B-1 have deteriorated due to ice-melting salts that enter the building on vehicles during the winter. A slab replacement program is ongoing and should be continued until all of the damaged slabs are replaced. The monitoring of the visco-elastic movement dampers in the two Towers is an essential program that has been strongly recommended for continuation by the PA's outside structural consultant. Building movement is monitored by analysis of measurements taken and recorded by devices located in the 108th floor of 1 WTC. Analysis of these records is done by the Port Authority's independent engineer (LERA) and should continue in the future. In addition, physical sampling and analysis of the condition of the visco-elastic dampers is reportedly continuing on a 5-year cycle, with the next sampling to be done in 2001. The slurry wall that surrounds and contains the subgrade levels of the complex has some seepage that is contained by curbing and leaders, and is discharged by sump pumps in the lowest levels.

The slurry wall and the adjacent floor slabs that brace the wall are inspected on an ongoing basis to ensure that unsafe conditions do not develop. Structural Integrity Inspection (SII) Report I-38, dated April 3, 1998, provided in the Data Room, found the conditions to be acceptable. These periodic inspections should continue.

The rating of the structural fireproofing in the Towers and subgrade has been judged to be an adequate 1-hour rating considering the fact that all Tower floors are now sprinklered. An ongoing program of re-fireproofing the structural steel to the full thickness for 2-hour rating is in place. This work is done on a lease rollover basis whenever there is a full floor of space being built out for new occupancy. To date approximately 30 floors have been completed in the two towers. The PA will require this program to continue. The presence of asbestos containing

structural fireproofing is documented and abatement in tenant spaces is being done in conjunction with lease rollovers. Abatement of asbestos containing fireproofing material in elevator shafts is ongoing. Air monitoring and physical inspections are carried out as part of the regular asbestos O&M Plan. Patching of non-asbestos fireproofing is handled through a program of in-house inspection and repair.

Exteriors

Building exteriors are generally functioning adequately. A regular program of inspection is carried on by ABM, the maintenance contractor, and is monitored by a private consultant engaged by the Port Authority. Exterior caulking and repairs are done as required based on the findings of the 2 inspecting agencies. Ongoing repair to the finishes on the 4 and 5 WTC buildings should be expected and, within the 10-year term, it would be advisable to consider a wet-seal and repainting program for those 2 buildings. There have been proposals for refinishing the 2 Tower buildings which, to date have not yet been implemented. This issue will also need to be addressed within the 10-year term. Other exterior conditions, which require ongoing monitoring, and repair as necessary are the exterior marble panels on some of the lower areas of the retail base of the complex and the exterior plaster soffits on the 4 and 5 WTC buildings.

There has been a problem with ice forming on and falling from the Towers during early and late winter months. The problem is most severe when the temperature at the upper Tower levels (which is several degrees colder than at the Plaza Level) falls below freezing. During high humidity days, ice balls can form and dislodge from the wall and roof surfaces. Damage to nearby buildings and injury to pedestrians has occurred. The Port Authority is well aware of this condition and the PA Police Department takes appropriate action to restrict access to sidewalks and the Plaza when the condition occurs. When surrounding streets are involved, the NYC Police are also advised and involved accordingly. There does not appear to be an architectural solution to this problem as it is caused by an unusual atmospheric condition. In addition, there are incidences of noise generated either by the movement of the Tower corner panels or by the movement of underlying back up deck material during high wind conditions when the Tower movement is significant. There are no signs that this movement has caused any damage to the panels or attachments at this time.

Roofs

The roofs of 1 and 2 WTC are the original membrane systems protected by rigid insulation and a 5" thick concrete overlay. These roofs appear to be serving adequately, with only local repairs to the spalled concrete wearing course required over the next 5 years. The roof of 4 WTC is nearing the end of its anticipated service life and replacement should be anticipated. The roof of 5 WTC was replaced in 1991 and may still be under warranty. Requirements for warranty transfer should be investigated. The bituminous membrane under the Plaza deck, which acts as the roof of the retail area, was examined extensively as part of the work done when the Plaza was refinished last year. There are still some chronic leaks at specific locations; such as at the Tower expansion joints and the expansion joint along the Church Street side, but these leaks are corrected as they occur as part of maintenance.

Interiors

Interior conditions are generally good. Full floor office tenants are reportedly responsible for all finishes on their floors. Finishes on the multi-tenant floors will continue to need periodic replacement. Rest room finishes are now about 25 years old and thought should be given to a phased program of modernization on multi-tenant floors. The 20" x 20" ceiling tiles used in some areas are no longer manufactured and the replacement of these ceilings with standard grid ceilings, rather than having custom tiles manufactured, is recommended when replacement or modernization is necessary. Remediation of deficient tenant separation walls and public corridor walls on office floors is being accomplished as new tenant spaces are built-out. While some of these walls do not extend to the underside of the slab, the condition is not deemed to be an immediate problem in this fully sprinklered facility. Vestibule entries for mechanical rooms entered from fire stairs will need to be added in phases.

The Mall spaces are in good condition with various recent build-outs by national retailers. Phased upgrades of Mall common area finishes have also begun, and consideration should be given to continuing the upgrading throughout the rest of the Mall. Monitoring of the Mall ceiling suspension system is done on a regular basis and should continue to be part of the normal maintenance program. Two additional means of egress have been added to the Mall circulation pattern, following a 1992 study by the World Trade and Engineering Departments. Installation of the third additional Mall egress is pending.

Vertical Transportation

The 238 WTC elevators are being maintained under a full-service contract with Ace Elevator. The survey by BOCA Group International, Inc. initially included visual observations of a pre-selected random sampling of 21 elevator and escalator devices at the buildings, and the review of available documentation pertaining to elevator maintenance and modernization programs. The sample elevators selected for observation were chosen to provide a representative specimen from each building and zone and included modernized, partially modernized, and original elevators. Following the initial sampling, BOCA further reviewed and observed additional devices based on callback data provided by the Vertical Transportation Department and on reports prepared by the Port Authority's independent elevator consultant. An evaluation of the maintenance indicates that "maintenance practices range from acceptable to marginally acceptable, with definite room for improvement in the area of housekeeping." In addition the elevator survey reported significant deficiencies that should be addressed under the terms of the full service contract. In general, it was reported that the service contractor is not proactive in addressing problems and that close oversight by the PA Vertical Transportation Department is necessary to maintain acceptable service and maintenance levels.

The modernization of all passenger cabs with new interior finishes, overlay controllers, ADA features, and firemen's recall has recently been completed. The second phase of the modernization program, including switching over from motor generator sets to SCRs, retrofitting door operators, and installing new door-reopening devices, is ongoing (126 completed, 8 in progress) and should be continued to completion (104 not yet modernized). The modernization is resulting in better service and a higher quality ride. When completed, the elevator system can be considered to be equal to those of new Class "A" office buildings. The high-rise shuttle cars in 1 and 2 WTC and the 6 and 7 cars in each Tower are equipped with "elevator followers" which are designed to eliminate rope impact on shaft elements. The venting of elevator shafts in the two towers is through the elevator machine rooms, due to the configuration of elevators over elevators in the central cores. This has been accepted as the only viable solution by the Port Authority as the Code enforcing agent. A test sample of the "Captivate" system, a high resolution monitor carrying news, weather, and internet information within elevator cabs was recently completed. The system is now to be installed throughout the complex.

All escalators have been modernized with start/stop switches, comb plate switches, demarcation lights, caution signs, controlled descent devices, and remote monitoring systems. Carl White devices have thus far been installed on 2 escalator units.

HVAC

The mechanical systems were adequately designed and constructed using brand-name equipment, which provides adequate cooling for the complex. The freeze protection system, recently installed in the 108th floor mechanical equipment room (MER) of 1 WTC, is budgeted to be installed in all the buildings' MERs so that air conditioning will be available throughout the year (especially during normally cooler months when the outdoor temperatures rise higher than normal).

The 2 Towers exhibit a stack effect where there is either high negative or positive pressures that effect the opening and closing of doors and emit loud noise through the elevator shafts. This is particularly noticeable when there are large differences between indoor and outdoor temperatures, especially in the winter and on very humid days. The stack effect will also cause smoke from any subgrade fires to be pulled upward into the building. For this reason, a smoke evacuation system for the PATH station has been designed and budgeted (see Life Safety in this section).

In 1985, Lucius Pitkin Consulting Engineers, an independent consulting firm, was hired to examine the welds on the high-pressure steam pipe risers. The Pitkin Report stated that many welds exhibited flaws, such as insufficient penetration and cracks in circumferential welds. The report recommended that all welds be examined and that any weld lacking 50% or less penetration be removed and repaired. To date this work has not been done, nor have any welds exhibited leaks. Based on the piping system's satisfactory history, we recommend that the program of monitoring the pipe welds be continued and that the leaks be repaired as they occur. We do not find any evidence that warrants any program of system-wide corrective action.

Although in operation, the majority of equipment is past its published service life, and replacement of the equipment should be anticipated. A major capital project to update the air handling systems has effectively increased the service life and reliability of the air handling equipment. Equipment and component replacement is now performed as part of the ABM service contract.

Since its original construction, the central refrigeration plant has been expanded to include an additional 10,000 tons of capacity and improved performance. Full winter operation of the chilled water systems is now possible and redundant river water piping systems allow for improved service and maintenance programs. Both refrigeration plants operate on R-22 refrigerant. The use of Hudson River water for the cooling plant is in compliance with environmental regulations.

Merritt & Harris, Inc. reviewed the findings of a report written by Jaros, Baum, & Bolles (JB&B), Consulting Engineers, New York, New York, dated October 31, 1996. The report was written for the Port Authority and JP Morgan & Co. Inc. It presented an evaluation of the physical condition of the existing Base Building HVAC, electrical, plumbing, and fire protection systems at the WTC. The WTC 1, 2, 4, and 5; the Mall; and the Subgrade were covered in the report. The majority of the JB&B report's findings addressed issues that we consider to fall within the category of normal maintenance. The Port Authority has addressed, or is in the process of addressing and correcting, the issues noted in the JB&B report. Our observations and reviews of documents have confirmed that the issues are being addressed.

Plumbing

The plumbing systems appear to be functioning satisfactorily. Although operational, the majority of plumbing equipment is past its published service life, and replacement of the equipment should be anticipated. Equipment component maintenance and repair is performed as part of the ABM service contract.

Water hammer arrestors, on a 2" water line in a wall on the 55th floor of Tower 1, recently failed flooding the 55th - 44th floors. Samples of the arrestors were sent out for independent evaluation. It was determined that the bellows in the arrestors failed due to repeated expansions and contractions over a 27-year period. Therefore, it is recommended that a program be undertaken to replace all water hammer arrestors in all buildings, before more failures and flooding occur.

Electrical

The electrical systems appear to be functioning satisfactorily, and adequate electrical capacity is provided for all of the buildings. Major upgrades have taken place including feeder and bus duct replacements. The main electric substations are not in compliance with NYC Code and there is no variance in place. The primary issne is the lack of ground fault protection provision before the switchboard. It is understood that the Port Authority approved this configuration, and since the Port Authority is expected to remain the Code interpreter for this installation, new requirements for compliance will not occur in the future. Some of the electrical substations have been modernized as part of a project-wide infrastructure program. In some of the smaller closets, there are clearance issues where new equipment has been installed. These installations are reportedly grandfathered until any new equipment is added and have been accepted by the Port Authority in its role as Code interpretation official. A new standby power plant, located on the roof of 5 WTC and distribution network (beyond that for emergency power), is available for tenant use. It is understood that an operating certification is not required for this installation since it is not intended for use as a co-generation facility.

Life Safety

The life safety systems are appropriate for this type of facility, and have been upgraded during the life of the complex. Currently a new fire alarm system is being installed throughout the facility, and this installation is addressing open issues including return air smoke detection and annunciation, elevator lobby smoke detector activation, public address loudspeakers, and standpipe telephone jacks. The Fire Command stations in each building have been completed and approved. The majority of spaces are sprinklered, except for main lobbies, electrical and mechanical spaces, and some toilet rooms. The sprinklering plan is consistent with the requirements of the New York City Building Code. A survey is required to determine which floors may have inadequate fire hose reach, and to establish a plan to make these floors become code-comforming.

Technically, the stairwells of the Tower buildings should be vented. Because of the height of the stairwells, however the installation of venting fans would not be practical and would, most likely, pull smoke into the stairways from the corridors, a condition that is not favorable. The Port Authority is aware of the lack of venting in the stairwells and, as the code enforcement agency, has accepted that the addition of venting would cause an unsafe emergency exiting situation.

Because of the stack effect, fumes and smoke from fires that may occur in the PATH station can migrate into the Mall area and eventually into the buildings. A plan to install smoke barrier drops at the PATH entrance ceiling and ducted smoke evacuation from the PATH station through the subgrade space have been approved and budgeted. This plan appears to be a sound one. We are informed that this work will begin shortly.

An egress study has been made which recommended that 3 additional means of egress be constructed in the Mall. Two exits were added and a third, exiting from the vicinity of the present Godiva Chocolatier shop, is planned and budgeted.

Energy Conservation

The buildings have a mix of clear single-pane glazing or tinted single-pane glazing. There is no energy management system, although the central plant control system can be used to check trends and manually optimize the equipment operation. It is of note that electrical power is provided by Consolidated Edison, but purchased directly from the New York Power Authority at a relatively low cost.

Maintenance

Electrical, HVAC and general maintenance is performed under the terms of a consolidated performance-based service contract by ABM Engineering, with oversight by the Port Authority World Trade Department's Building Services Management Division. In general, maintenance of the systems appears to be adequate. Housekeeping (cleaning) deficiencies were noted in stairwells, electrical closets, and service areas. Ongoing repairs and replacement of components were observed to be in progress in various areas. It should be noted that the ABM Engineering contract calls for both the maintenance and repair of equipment. If a new contract is entered into with a service company for maintenance only, the replacement of equipment must be accounted for separately.

ADA Accessibility

The office building entrances, travel routes, and elevators are ADA compliant. ADA compliance on most full tenant floors is reportedly the responsibility of the tenants under terms of the leases (Merritt & Harris, Inc. did not review the leases), which would be a common practice. ADA compliance for toilet rooms on multi-tenant floors is a building owner's responsibility. Upgrades to toilet rooms, signage, and door hardware for building common spaces should be made on multiple-tenant floors.

The Mall has ADA-accessible entrances on grade in numerous clearly marked locations. All ADA entrances have power-assist doors. Although the 2 Mall levels are individually accessible, interior interconnection between the Concourse and the Plaza Levels is available only by ramp and elevator in the 5 WTC building, the office building elevators in 4 WTC, and a private tenant elevator in the Border's Store. We recommend that the redevelopment of the vacant retail space in the southeast section (4 WTC area) include consideration for a public elevator in the Mall common area to streamline ADA access between levels. Public rest rooms in the Mall are accessible as defined by the ADA.

Violation Status

As stated in the Offering Memorandum, "The Port Authority is a municipal corporate instrumentality and political subdivision of the States of New York and New Jersey which provides transportation, terminal, and other facilities of commerce within the Port District. As such, in connection with the Transaction, the PA will continue to maintain exclusive jurisdiction with respect to certain administrative and governmental matters involving the Complex, including compliance with building, environmental, fire and health codes." The New York City Department of Buildings has indicated that they do not maintain any records of violations for this property. A request for a Property Profile Overview for this block and lot number yields no records. The Fire Department provides normal fire fighting and a life safety service to the facility. A Memorandum of Understanding exists between the Port Authority and the Fire Department in which the Fire Department performs regular inspections and directly notifies the Port Authority Fire and Life Safety group of deficiencies to be corrected. Under a protocol with the New York City Fire Department, Port Authority Police personnel investigate certain fire alarms at the World Trade Center rather than transmitting such alarms to the New York City Fire Department.

Environmental Site Assessment

During construction, essentially all soil down to 75' was removed, eliminating any potential pollution from previous uses of the site. R.W. Crandlemere & Associates identified other locations of recognized environmental conditions in the search radius, but concludes that none of these sites or the current use of the WTC, are likely to impact the environmental integrity of the subject site.

The use of Hudson River water for the cooling plant is in compliance with regulations. The current NYDEC State Pollutant Discharge Elimination System (SPDES) permit extends to May 1, 2004. Monitoring reports and SPDES inspections performed in 1999 and 2000 state, "no reported permit limit exceedences."

The 1999 Denny & Associates report concerning the broadcasting and transmission devices mounted on the roof of WTC1 were reviewed. Operational guidelines are currently in place to provide protection to trained workers and escorted visitors. Based on the Denny & Associates report, R.W. Crandlemere & Associates recommends further additional investigation concerning radio frequency exposure levels for visitors to the observation deck on 2 WTC.

The R.W. Crandlemere & Associates *Environmental Site Assessment* is included in its entirety in this report.

Asbestos

Asbestos-containing materials (ACM) were used as sprayed-on fireproofing and pipe insulation during the original construction. Vinyl-asbestos tile is present throughout the complex. The Port Authority has identified the areas having ACM, which are primarily tenant spaces, mechanical rooms, subgrade areas, and elevator shafts. A large portion of the ACM has been removed and the abatement process is continuing as tenant leases rollover and the spaces are retrofitted. Some abatement projects are carried in the capital budgets for 2001-2005 and other VAT and spray-on abatement work is treated as an operating cost. An Operations and Maintenance Plan has been produced and specific staff personnel have been trained and certified as ACM handlers to deal with incidental disturbance of the material. Much of the ACM in the pipe insulation in the subgrade areas has been removed. Tenants occupying floors that may still contain asbestos material have been formally notified.

There is a reported litigation in process for cost recovery related to ACM abatement. This litigation was not reviewed as part of this report and questions pertaining to the subject should be addressed to the appropriate legal entity.

R.W. Crandlemere & Associates reports addressing the presence of ACM are provided in each individual building section of this report.

Specific Recommendations

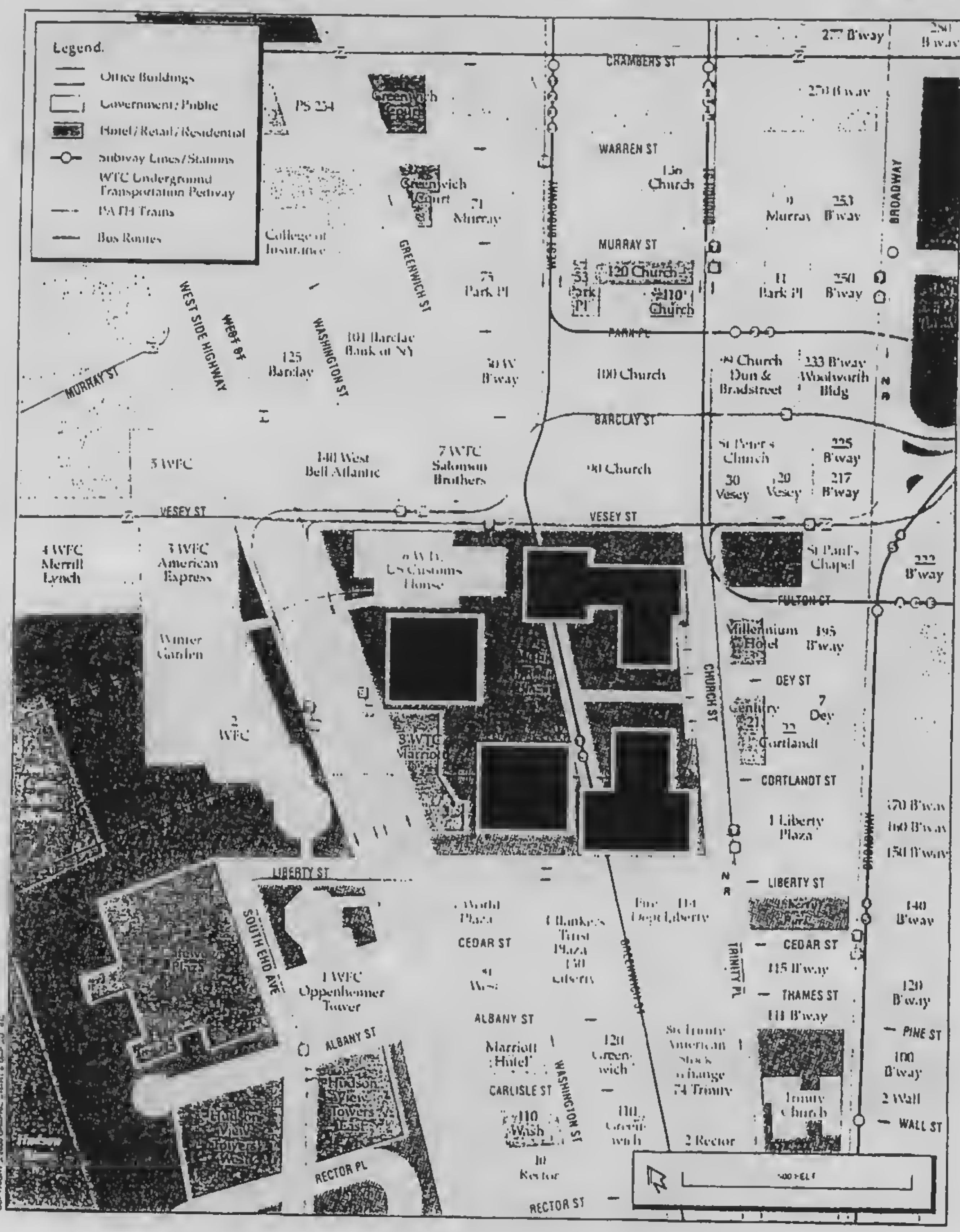
Specific recommendations, items of concern, and building deficiencies are noted in "**E. Recommendations**" section of the individual property component reports. Priorities are divided into **Immediate (0-1 Year)**, **Future (1-5 Years)** and **Future (6-10 Years)** categories.

EXECUTIVE SUMMARY ATTACHMENTS

1. Neighborhood Map (Reproduced with permission from J.P. Morgan Property Book)
2. Résumés of participating Merritt & Harris, Inc. staff personnel
3. Due Diligence Check List of Documents as of October 31, 2000
4. WTC - Proposed 2001 Capital Plan
5. WTC - Proposed 2002-2005 Capital Plan
6. R.W. Crandlemere & Associates Environmental Site Assessment Phase I Report (separate binder)
7. BOCA Group International, Inc. - Overall Observation

ATTACHMENT 1

Neighborhood Map
(Reproduced with permission from J.P. Morgan Property Book)


Legend.
Office Buildings
Government/Public
Hotel/Retail/Residential
Subway Lines/Stations
WTC Underground Transportation Pathway
PATH Trains
Bus Routes
CHAMBERS ST
WARREN ST
MURRAY ST
PARK PL
BARCLAY ST
VESEY ST
FULTON ST
DEY ST
CORTLANDT ST
LIBERTY ST
CEDAR ST
THAMES ST
PINE ST
WALL ST
ALBANY ST
CARLISLE ST
RECTOR ST
RECTOR PL
WEST BROADWAY
CHURCH ST
BROADWAY
GREENWICH ST
WASHINGTON ST
WEST SIDE HIGHWAY
SOUTH END AVE
TRINITY PL
PS 234
Greenwich Court
College of Insurance
71 Murray
75 Park Pl
101 Barclay Bank of NY
125 Barclay
30 W B'way
100 Church
90 Church
5 WFC
140 West Bell Atlantic
7 WTC Salomon Brothers
4 WFC Merrill Lynch
3 WFC American Express
6 WTC US Customs House
Winter Garden
2 WFC
3 WTC Marriott
1 WFC Oppenheimer Tower
Marriott Hotel
10 Rector
2 Rector
Hudson View Towers
120 Church
110 Church
33 Park Pl
136 Church
St Paul's Chapel
Millennium Hotel
195 B'way
7 Dey
Century 21
22 Cortlandt
1 Liberty Plaza
170 B'way
160 B'way
150 B'way
140 B'way
120 B'way
100 B'way
2 Wall
115 B'way
111 B'way
Trinity Church
277 B'way
270 B'way
253 B'way
250 B'way
233 B'way Woolworth Bldg
225 B'way
217 B'way
222 B'way
11 Park Pl
30 Vesey
20 Vesey
St Peter's Church
Dun & Bradstreet
CEDAR ST
ALBANY ST
120 Greenwich
110 Greenwich
110 Wash
74 Trinity
Fire Dept
114 Liberty
LIBERTY ST
500 FEET

ATTACHMENT 2

Resumes of participating Merritt & Harris, Inc. staff personnel

THOMAS C. RICHARD, AIA

President & Chief Executive Officer

ACCREDITATION	Registered Architect in the State of New Jersey
PROFESSIONAL AFFILIATIONS	New Jersey Society of Architects Architects League of Northern New Jersey American Institute of Architects (AIA) American Society for Testing and Materials (ASTM) Mortgage Bankers Association - New York Urban Land Institute
EDUCATION	Bachelor of Arts, Fordham University School of Architecture, Pratt Institute
MERRITT & HARRIS, INC. *New York, NY*	Mr. Richard joined the consulting firm in 1981 as a Project Manager and was appointed Vice President in 1984. In 1987 he was named Senior Vice President & Principal heading the Due Diligence Division, which provides total building evaluation services to the real estate financing and investment community. In 1996, Mr. Richard became President & CEO of Merritt & Harris, Inc.
HARSEN & JOHN PARTNERSHIP ARCHITECTS *Tenafly, NJ*	Employed as a Senior Project Supervisor, Mr. Richard worked for the architectural firm from 1969 through 1976. His responsibilities included design and construction supervision of multi-million dollar educational, municipal, and multi-family housing projects. Mr. Richard rejoined the partnership in 1978 as the Director of Operations, with supervisory control of design, document production, construction, and administrative functions of that forty person office, and organized a subsidiary architectural interiors company.
G&R SERVICES *Bogota, NJ*	From 1976 to 1978 Mr. Richard was a partner of a design/build construction company. His duties included administration, construction supervision, design, and estimating. He served as on-site Educational Facilities Design Consultant to the Federal Republic of Nigeria for the design of the National Educational Technology Center in Kaduna, Nigeria.

ROBERT G. WEILAND, R.A.

Principal - Due Diligence

ACCREDITATION	Registered Architect in the State of New York
EDUCATION	Bachelor of Architecture, Pennsylvania State University Graduate Study - Architectural Technology, Columbia University
MERRITT & HARRIS, INC. *New York, NY*	Mr. Weiland joined the consulting firm in 1984 as a Project Manager and evaluated various projects throughout the United States. His responsibilities include review of construction drawings and specifications, and field observation of new and existing construction. Appointed Vice President in 1988, he assumed the responsibilities of coordinating nationwide, multi-site portfolio observations, and developing formats for the presentation of real estate tax appeal projects for municipal government clients. In 1996, Mr. Weiland was appointed a Principal of Merritt & Harris, Inc.
Major Projects	Chrysler Building - New York, NY Macy's Portfolio - Various Nationwide Locations IBM Tower - Atlanta, GA Rockefeller Center - New York, NY Alamoana Shopping Center - Honolulu, HI
IFFLAND, KAVANAGH, WATERBURY, PC *New York, NY*	An Associate of the firm, Mr. Weiland was responsible for industrial, commercial, and television broadcast projects, from initial client contact through program development. His duties also included the production of construction drawings and specifications, and supervision of construction. He was an employee of the firm from 1978 to 1984.
MARINE MIDLAND BANK *New York, NY*	Mr. Weiland worked for the bank as an Architectural Designer in the facilities management department from 1974 to 1978. His job responsibilities entailed client contact for program development and preliminary design, as well as construction document preparation and field supervision for the construction of corporate office facilities and branch banks.
URS/MADIGAN - PRAEGER *New York, NY*	As a Project Architect in 1973, Mr. Weiland prepared construction documents and made field inspections for renovation projects including, municipal garages, stadiums, and waterfront facilities.

JACK M. KAGAN

Principal - Mechanical/Electrical Engineer

ACCREDITATION	Certified, National Board of Boiler and Pressure Vessel Inspectors Certificate of Competency, State of New York Department of Labor, Bureau of Boilers
PROFESSIONAL AFFILIATION	American Society of Mechanical Engineers
EDUCATION	Associates Degree in Applied Science - Mechanical Technology, New York City Community College Bachelor of Mechanical Engineering Degree, Pratt Institute
MERRITT & HARRIS, INC. *New York, NY*	Mr. Kagan joined the consulting firm in 1984 as a Mechanical Maintenance Equipment Specialist. His responsibilities included design review of mechanical, plumbing, electrical plans and specifications, and field evaluation of new and existing construction. In 1988 Mr. Kagan was named Assistant Vice President-Electro/Mechanical Engineer. Mr. Kagan was appointed a Principal of Merritt & Harris, Inc. in 1996.
Major Projects	Ice Palace - Tampa, FL Chrysler / Kent Buildings - New York, NY Las Colinas Office Buildings - Dallas, TX The Waikaloa Resort - Honolulu, HI Greenway Office Towers - Houston, TX
ROYAL INSURANCE CO. *New York, NY*	As a member of the Boiler and Machinery Department from 1981 to 1984, Mr. Kagan was responsible for the technical support of sixty-five field offices and home office departments, for all phases of boiler and machinery equipment insurance.
HEMPSTEAD RESOURCES RECOVERY *Garden City, NY*	Mr. Kagan worked as a process supervisor from 1978 to 1980 and was responsible for the processing of two thousand tons of municipal garbage per day for metals recovery and fuel production for a 40 MW electric generating station.
E.I. DUPONT *Newark, NJ*	Serving as a mechanical supervisor in the Engineering Department, Mr. Kagan was responsible for project engineering, minor construction, and powerhouse and waste treatment operations. He also served as Production Supervisor in the Organic Color Pigments Finishing Department. Mr. Kagan worked at E.I. DuPont from 1974 to 1978.

PETER J. BRADY, P.E.

Project Manager -Due Diligence

ACCREDITATION	Professional Engineer in New York State
EDUCATION	Bachelor of Civil Engineering, City College, City University of NY Master of Civil Engineering, City College, City University of NY
MERRITT & HARRIS, INC. *New York, NY*	Mr. Brady joined the consulting firm in 1994 as a Project Manager for the evaluation of various projects throughout the United States. His responsibilities include the review of construction drawings and specifications, and field observation of new and existing construction.
Major Projects	DisneyWorld Swan & Dolphin Hotels - Orlando, FL Hato Rey Tower - San Juan, Puerto Rico Ritz Carlton - Naples, FL West Port Plaza - St. Louis, MO Wolfchase Galleria - Memphis, TN
DEPARTMENT OF HOUSING PRESERVATION & DEVELOPMENT *New York, NY*	Mr. Brady was hired in 1960 as an Assistant Civil Engineer. His responsibilities included being a field engineer for all phases of hi-rise residential construction. Promoted to Civil Engineer in 1964, his new responsibilities included the review of hi-rise plans and specifications for code compliance, coordination, and completeness. As a Senior Civil Engineer, Mr. Brady supervised engineers on review and coordination of plans and specifications. In 1972 Mr. Brady was promoted to Chief of Engineering and Construction for the New York HPD's Middle Income Housing Program. During the 1980s he directed the HPD's conversion from new construction to substantial and moderate rehabilitation. He developed procedures and forms for recording and evaluating the condition of vacant/vandalized buildings. Mr. Brady also prepared construction standards for compliance with various loan program requirements, and developed parameter cost estimating procedures using personal computers and spreadsheet packages.

JOSEPH J. MARCIANO, P.E.

Mechanical/Electrical Engineer

ACCREDITATION	Licensed Professional Engineer in the State of New York
PROFESSIONAL AFFILIATION	Member, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE)
EDUCATION	Bachelor of Science, Cornell University Construction Management Diploma - The Real Estate Institute at NYU
MERRITT & HARRIS, INC. *New York, NY*	Mr. Marciano joined the firm as a Mechanical Engineer in 1996. His job responsibilities include design review services for adequacy and completeness of mechanical and electrical systems for new construction and renovation work. Mr. Marciano's due diligence work includes detailed reviews of the HVAC, plumbing, electrical, life safety, and energy conservation systems of existing buildings.
Major Projects	Warner Theater Building - Washington, DC Blanchard Plaza - Seattle, WA Greenwich Office Park - Greenwich, CT Reston Town Center - Reston, VA West Port Plaza - St. Louis, MO
COMPREHENSIVE DEVELOPMENT CORPORATION *New Rochelle, NY*	As a Construction Consultant from 1991 through 1996, Mr. Marciano provided estimating, scheduling, and claim servicing, as a well as site evaluations, and plan review and coordination. His various responsibilities, included coordinating the mechanical, electrical, and plumbing work at two primary schools for the New York City School Construction Authority. Mr. Marciano also coordinated the contractors in the field, maintained the project records and interfaced with the designers and the client.
NASCO ASSOCIATES *New York, NY*	Mr. Marciano served as a Project Manager and Senior Estimator for this construction management and consulting firm. He specialized in field coordinating and project cost estimating during all stages of design, from conceptual to final, including change order evaluation. Other duties included scheduling, inspecting, handling contractor claims and performing value engineering studies. Mr. Marciano also served as an engineering audit officer on the Stuyvesant High School project in Battery Park City. Mr. Marciano worked for Nasco Associates from 1987 to 1991.

ATTACHMENT 3

Due Diligence Check List of Documents

WORLD TRADE CENTER
DATA CENTER
DUE DILIGENCE CHECKLIST
(As of October 31, 2000)

ITEM			
A	GENERAL PROPERTY INFORMATION		
	1	Offering Memorandum (x2)	
	2	Property Book (x2)	
B	LEASING INFORMATION		
	1	Argus Rent Roll as of 10/1/00	
	2	Port Authority's Rent Roll	
	3	WTC Fixed Billing System as of 11/1/00	
	4	Leasing Activity Reports	
		a.	June-Current 2000
	4	Retail Sales Reports	
		a.	1998 & 1999
		b	Year to Date 2000
		c	Total Sales by Store - First Six Months (2000 vs. 1999)
	5	Port Authority ("PA") Comptroller's Suffix Descriptions for WTC Fixed Rent Roll	
	6	Copies of Retail, Office and Subgrade Leases and Lease Abstracts	
		a.	Office Tenants
		b	Retail Tenants
		c	Subgrade Tenants
		d	Telecommunication/Broadcasting Tenants
	7	Leases Under Negotiation and Expected Terms for 2000	

ITEM				
	8	PA Comptroller's List of WTC Percentage Agreement Tenants		
	9	Telecommunication/Broadcasting Agreements		
		a.	Summary of deals	
	10	Copies of Existing Ground Leases		
		a.	Marriott Hotel	
			i	Privilege Permit dated as of 1/1/98 to HMH WTC, Inc.
		b	Customs House	
	11	Remeasurement Study		
C	FINANCIAL INFORMATION			
	1	WTC Allocation Methodology Summary of Financial Statements included in the Offering Memorandum		
	2	2000 PA Operating Forecast		
	3	Historical Operating Statements [1997-1999]		
	4	Payroll		
	5	Real Estate Taxes		
		a.	Current Assessed Valuation for Block 58, Lot 1	
		b	Agreement between the PA and the City of New York, dated as of 1967 regarding Payments in Lieu of Taxes ("PILOT")	
		c	1999/00 letter to New York City ("NYC") Explaining PILOT Calculation	
	6	Agreement between the PA and The Alliance For Downtown New York, Inc., with respect to BID Payments		
		a.	February 9, 1995 Agreement	
		b	December 24, 1998 Amendment	
	7	Capital Expenditures		
		a.	Updated Capital Plan	
	8	Miscellaneous		

ITEM		
	a.	10/1/00 Rental Receivables Reports
D	ENVIRONMENTAL INFORMATION	
	1	Summary of Environmental and Asbestos Due Diligence
	2	Asbestos Records, including a disclosure memo, identifying known locations of asbestos-containing materials; abatement project files; quantities removed; and estimates of remaining quantities
	3	Known Location of Asbestos
	4	NYS DEC State Pollutant Discharge Elimination System (SPDES) Discharge Permit, dated 4/12/99
	5	Annual Regulatory Permits/Licenses, including Petroleum and Chemical Bulk Storage
		a NYS DEC Petroleum Bulk Storage Registration Certificate, issued 8/4/98
	6	Hazardous Materials Response Plans, inventories and certificates
	7	Hazardous Waste Manangement records and inspections
	8	Annual U.S. Environmental Protection Agency SARA Title III Community-Right-To-Know Inspection Reports-Tier II
	9	Annual New York State Department of Environmental Conservation Annual Environmental Audit and Toxic Release Inventory
	10	Evaluation of Radio Frequency Environment at the WTC-North Tower (Richard Tell 9/97)
	11	RE-Evaluation of Radio Frequency Environment at the WTC-North Tower (Supplemented 9/5/99, revised 3/21/00)
	12	Denny & Associates: Electromagnetic field strength survey - South Tower (1/99)
	13	Investigation of RF Safety Cosiderations on the WTC Antenna Mast (Richard Tell 5/12/00)
	14	Condenser, Hot & Chilled Water Report as of 9/30/00
	15	United States of America Federal Communications Commission Antenna Structure Registration, issued 3/23/98

ITEM		
E	OPERATING AND MAINTENANCE MANUALS	
	1	River Water Pump Station - Vol. 1
	2	Remote Lighting Control System - Vol. 2
	3	Chiller Plant Addition B6 Refrigeration Plant - Black Binder
	4	Mechanical System: Central Refrigeration Plant - Vol. 3
	5	Mechanical System: Central Refrigeration Plant (2500 ton chillers) - Vol. 3A
	6	Electrical System: Central Refrigeration Plant - Vol. 4
	7	Electrical System: Central Refrigeration Plant (2500 ton chillers) - Vol. 4A
	8	High Voltage Distribution System - Vol. 5
	9	Low Voltage Distribution System, Towers A & B - Vol. 6
	10	Emergency Power Distribution System - Vol. 8
	11	Plaza Sculpture Fountain System - Vol. 9
	12	Low Voltage Distribution System, NEPB & SEPB - Vol. 10
	13	Low Voltage Distribution System, Subgrade Levels - Vol. 11
	14	Smoke Detection System-Observation Deck, Tower B - Vol. 12
	15	Domestic Water System: Tower A & B - Vol. 14
	16	HVAC System Tower A & B - Vol. 15
	17	Elevator System - Vol. 20
	18	Antenna Heating System - Tower A - Vol. 21
	19	Fire Protection System - Vol. 23
	20	Sewage & Sump System Sublevels Tower A & B - Vol. 25
	21	Window Washer & Exterior Platform Equipment Towers A & B - Vol. 31
	22	Window Washing & Exterior Wall Maintenance Systems SEPB & NEPB - Vol. 32

ITEM			
	23	Computer Cooling Water System - Towers A & B - Vol. 33	
	24	Computer Cooling Water System - NEPB & SEPB - Vol. 34	
F	PERFORMANCE INDICATORS		
	1	Fourth Quarter '99, First & Second Quarter '00	
G	CAPITAL EXPENDITURE CONTRACTS		
	1	Memorandum summarizing Elevator Modernization Programs	
H	SERVICE CONTRACTS		
	1	Contract WTC-799.700: Amendment No.1 to Agreement to Perform Maintenance of Elevators, Dumbwaiters & Escalators: 1,2,4,& 5 WTC (3/18/99)	
	2	a	Contract WTC-891.073: Furnish, Install and Configure Office Space Security System Software at the World Trade Center
		b	Contract WTC-799.610: Maintenance of Office Space Security System Software at the WTC (5/94)
	3	Contract WTC 845.071: Modernization of Elevators, Dumbwaiters and Escalators: 1 WTC (3/94)	
	4	Contract WTC 838.071: Modernization of Elevators and Escalators- 4 & 5 WTC (9/93)	
	5	Contract WTC 846.071: Modernization of Elevators and Escalators 2 WTC (3/94)	
	6	WTC Agreement No. 990102: Provision of Construction Management Services on a "Call-In" Basis	
	7	TDI Advertising Contract (The Mall)	
	8	Contract WTC 799.60: Ironbound Flooring Installation	
	9	Contract WTC 891.074: Purchase of Key & Lock Cylinder System (office space security system hardware)	
	10	Contract WTC 799.47A: Maintenance Painting via Work Order 1, 2, 4 & 5 WTC	
	11	Contract WTC 822.071: Emergency Power For Condenser Water System No. 1	

ITEM	
12	Fire Alarm Maintenance Replacement Parts & Technical Services (Req. #52618)
13	Contract WTC 799.39: Maintenance of Centrifugal Refrigeration Machines with Supplemental Agreement and Extension
14	Contract WTC 799.710: Agreement to Perform Consolidated Electrical, Mechanical & General Maintenance Services
15	Contract WTC 799.688: Provide Maintenance of Six (6) Diesel Generators
16	Exercise of Option Period Agreement with Grand Central Neighborhood Social Services Corp. to Provide Labor for the Collection and Sorting of Recyclable Paper
17	Contract PSE - 727: Refinishing & Restoration Services of the Stainless Steel Surfaces – Concourse, Skylobby Levels of 1, 2, 4 & 5 WTC
18	Contract PSE - 801: Restoration of Stainless Steel & Other Metal Surfaces
19	Cleaning & Cleaning Related Services – Request for Proposals
20	Contract PSE - 864: Collection of Recyclable Waste Paper – Agreement with Manhattan Bowery Management Corp., NY
21	Contract PSE - 634: Trash Removal & Recycling Service at the WTC
22	Contract PSE - 821: Refuse Removal, Recycling & Disposal
23	Contract PSE - 821: Refuse Removal, Recycling & Disposal at WTC for 2 years
24	Contract PSE - 850: Removal of Construction Debris from the WTC
25	Contract WTC-463.00: Removal of Construction Rubbish, dated June 1995
	a Assignment and Assumption with Consent of Contract WTC-463.00: Removal of Construction Rubbish, dated October 1996
26	Contract WTC-697.00: Construction Labor Services
	a Amendment Number One to Contract WTC 697.00: Construction Labor Services
27	Contract WTC-457.03: Design Build Services for 1, 2 & 3 WTC

ITEM		
	28	Maintenance of Office Space Security System Software
	29	Contract WTC 799.56A: Agreement to Provide Fire Safety Director Service-1,2,4 & 5 WTC
	30	Design/Build Services for Tenants
	31	Contract WTC 799.690: Fire Alarm System Service Agreement for the World Trade Center Complex
	32	Contract WTC 115.300: Removal and Disposal of Vinyl Asbestos Floor Tiles and Other Asbestos-Containing Material Via Work Order (11/99)
	33	Contract WTC 881.072: Rehabilitation of B-1 Level (Truck Dock) Floor Slab (9/99)
I	STRUCTURAL INTEGRITY INSPECTION REPORTS by LESLIE E. ROBERTSON	
	1	Concourse, Subgrade, Marriott Back of House, 4 & 5 WTC Space Usage (11/20/98)
	2	Concourse, Subgrade, Marriott Back of House, 4 & 5 WTC Space Usage (12/24/97)
	3	River Water Pump Station (9/22/98)
	4	River Water Pump Station (4/28/95)
	5	Concourse Plaster Ceilings (9/18/98)
	6	Accessible Columns - 4 & 5 WTC (8/19/98)
	7	Elevator Pits & Machine Rooms - 1, 2, 4 & 5 WTC (10/30/99)
	8	Elevator Pits & Machine Rooms - 1, 2, 4 & 5 WTC (7/20/98)
	9	Elevator Pits & Machine Rooms - 1, 2, 4 & 5 WTC (12/18/97)
	10	Exterior Plaster Soffits - 4 & 5 WTC (7/20/00)
	11	Exterior Plaster Soffits - 4 & 5 WTC (7/15/98)
	12	Exterior Plaster Soffits - 4 & 5 WTC (8/31/96)
	13	Space Usage Survey - 1 & 2 WTC (6/15/98)
	14	Space Usage Survey - 1 & 2 WTC (7/31/97)

ITEM	
15	Space Usage Survey - 1 & 2 WTC (9/20/96)
16	Space Usage Survey - 1 & 2 WTC (9/20/96)
17	Slurry Walls & Adjacent Slabs - 1 & 2 WTC (6/98)
18	Slurry Walls & Adjacent Slabs - 1 & 2 WTC (5/28/97)
19	Slurry Walls & Adjacent Slabs - 1 & 2 WTC (7/16/96)
20	Accessible Columns - 1 & 2 WTC (5/30/98)
21	Accessible Columns - 1 & 2 WTC (5/23/97)
22	Accessible Columns - 1 & 2 WTC (5/1/96)
23	Floor framing - 4&5 WTC (7/24/98)
24	Plaza Level Box Columns (5/8/98)
25	Lobby Ceilings - 1 & 2 WTC (5/1/98)
26	Lobby Ceilings - 1 & 2 WTC (6/30/97)
27	Accessible Columns - 4 & 5 WTC (1/26/98)
28	Marble Panel Wall Inspection - 3, 4, 5 & Concourse Level at WTC (1/15/98)
29	Marble Panel Wall Inspection - 3, 4, 5 & Concourse Level at WTC (10/1/97)
30	Concourse Ceilings (5/23/00)
31	Concourse Ceilings (1/7/98)
32	Television Mast - 1 WTC (1/7/98)
33	Television Mast - 1 WTC (8/14/95)
34	Floor Frequency Measurements - 1 & 2 WTC (4/20/95)
35	Fire Stairs - 1 & 2 WTC (4/28/95)
36	Accessible Columns - 4 & 5 WTC (4/28/95)
37	Accessible Columns - 1 & 2 WTC (4/14/95)
38	Natural Frequency Measurements - 1 & 2 WTC (4/12/95)
39	Slurry Walls & Slabs at Slurry Walls (4/3/95)

ITEM	[illegible]
40	Slabs, Partitions, Finishes and Floor Framing - 1 & 2 WTC (4/1/95)
41	Marble Panels - 1 & 2 WTC (3/13/95)
42	Marble Panels - 1 & 2 WTC (10/1/97)
43	Marble Panels - 1 & 2 WTC (8/30/99)
44	Bracing of 1 & 2 WTC below Elev. 294' – 0" (3/1/95)
45	Marble Panels - 3, 4, 5 & 6 WTC & Concourse Level (2/22/95)
46	Hat Truss between Floor 107 & the Roof (2/21/95)
47	Lobby Ceilings (1/17/95)
48	Crown Framing Deterioration - 1 & 2 WTC (11/16/94)
49	Exterior Plaster Soffits - 4, 5 & 6 WTC (11/21/97)
50	Exterior Plaster Soffits - 4, 5 & 6 WTC (5/28/92)
51	Concourse Plaster Ceilings - 4 & 5 WTC (5/1/91)
52	Damper Testing - 1&2 WTC (5/28/96)
53	Subgrade levels - WTC Facility Condition Survey Report (3/96)
54	Floor Slabs, Partitions, Column Finishes - 1&2 WTC (12/10/97)
55	Mechanical Equipment Rooms - 1&2 WTC (5/99)
56	Mechanical Equipment Rooms - 1&2 WTC (4/12/96)
57	B5 & B6 Passageway & Storage Area -WTC Subgrade (8/12/97)
58	Concrete Slabs, Partitions Column Finishes & Floor Framing over Tenant Spaces -1&2 WTC (6/28/96)
59	WTC Spray Fire Protection Tower Spandrels & Diagonals (10/1/96)
60	Tower Subgrade Levels WTC Facility Condition Survey Report (3/96)
61	WTC River Pump Station, U.S. Customs House Soffit, Plaza Level Slab & Concourse Level Ceiling Facility Condition Survey Reports (6/96)
62	Northeast & Southeast Plaza Buildings Facility Condition Survey Report(11/95)

ITEM		
	63	Northeast & Southeast Plaza Buildings Facility Condition Survey Report (9/94)
	64	Report on WTC Sidewalks (MEDD Architects 7/2 7/99)
	65	WTC Subgrade Parking Garage Slabs (1/00)
	66	1,2,4 & 5 WTC, Floor Framing (11/29/99)
	67	4 & 5 WTC, Mechanical Equipment Rooms (10/99)
	68	1 WTC, Pedestrian Access Bridges (9/28/99)
	69	4 & 5 WTC, Cantilever Trusses & Exterior Plaster Soffits (9/99)
	70	1 & 2 WTC, Floor Framing Inspection, Action Memo 1 (8/23/99) & Action Memo 2 (9/8/99)
	71	4 & 5 WTC, Floor Framing - Action Memo 1 (8/10/99)
	72	6 WTC Exterior Plaster Soffits (7/16/99)
	73	1 WTC, Natural Frequency Measurements (7/11/00)
	74	1 & 2 WTC, Crown Framing (6/30/99)
J	FACADES	
	1	Curtainwall - 1&2 WTC (Facades)
	2	Curtainwall and Roof Inspection - 1&2 WTC (10/29/99)
	3	Curtainwall - 4&5 WTC (Facades)
	4	Curtainwall and Roof Inspection - 4&5 WTC (4/28/95)
	5	Curtainwall and Roof Inspection - 4&5 WTC (10/9/98)
	6	1996 Structural Integrity Inspections - 1&2 WTC Facades
	7	1997 Structural Integrity Inspections - 1&2 WTC Facades
	8	1998 Structural Integrity Inspections - 1&2 WTC Facades
	9	Curtainwall reinspection 10% (10/29/99)
K	MECHANICAL REPORTS/INFORMATION	
	1	Maintenance Management Evaluation (6/99)
	2	Steam trap evaluation report (8/6/99)

ITEM			
	3	Lucius Pitkin's Eddy Current Survey	
		a.	York Centrifugal Unit 2 (6/22/98)
		b	York Centrifugal Unit 3 (6/22/98)
		c	York Centrifugal Unit 5 (6/22/98)
		d	York Centrifugal Unit 6 (6/22/98)
		e	York Centrifugal Unit 1, 4 & 7-condensers and York Centrifugal Units 2, 3, 4-chillers (6/30/99)
		f	York Centrifugal Units 8, 9, 10, 11 & 12-condensers (7/21/99)
	5	Summary memo of WTC River Water Lines (9/6/00)	
	6	WTC 1,2,4,5 & Subgrade Air Handling Unit Rehabiliation (set of drawings) (5/13/98)	
L	VERTICAL TRANSPORTATION PROFILE & INSPECTION REPORTS		
	1	Elevators	
		a.	1 WTC (Cars 1-99)
		b	2 WTC (Cars 1-99)
		c	4 WTC (Cars 1-12)
		d	5 WTC (Cars 1-9)
		e	Subgrade Cars-1WTC (P1, J1-J4)
		f	Subgrade Cars-2WTC (K1-K5)
		g	4WTC (FE1-FE4)
	2	Escalators	
		a.	1 WTC: A1-A8
		b	2 WTC: B1 - B14
		c	S.E. Plaza (E14-E15)
		d	N.E. Plaza (E1-E13)
		e	PATH Escalators: P1-P11; P24; P27-P29
		f	Mall Escalators: E1, E2, E11-15, E17

51

ITEM		
3	Controller Manual s & Prints for Modernized Elevator Cars	
	a	ACE Elevator Co. CEC Futura Manual PA Contract #WTC 838.071, SEP Bldg. 4 Cars 1-6
	b	ACE Elevator Co. CEC Futura Manual Contract #WTC 838.071, SEP Bldg. 4 Cars 7-12
	c	ACE Elevator Co. CEC Futura Manual Contract #WTC 838.071, SEP Bldg. 5 Cars 1-6
	d	ACE Elevator Co. CEC Futura Manual & Diagram for Cars 12B, 13B PA Contract #WTC 846.071
	e	ACE Elevator Co. CEC Futura Manual Contract #WTC 845.071 SEP Bldg. 1 Cars 24A-29A
	f	ACE Elevator Co. CEC Futura Manual PA Contract #WTC 845.071, Bldg. 1 Cars 30A-35A
	g	ACE Elevator Co. Futura Manual & Magnetek DSD412 Manual Contract WTC 845.071, Bldg. 1 Cars 36A-41A
	h	ACE Elevator Co. CEC Futura Manual PA Contract #WTC 845.071, Bldg. 2 Cars 51A-56A
	i	ACE Elevator Co. Futura and Magnetek DSD412 Manual, Bldg. 1 Cars 87A-92A
	j	ACE Elevator Co. Controller Diagram for cars #93A-98A, PA Contract #WTC-845.071
	k	ACE Elevator Co. CEC Futura Manual PA Contract #WTC 845.071, 14 & 15A
	l	A.C.E. Elevator Co. Inc., Swift Futura, CEC Job No. 3331 cars 14A, 15A 1WTC Velocity/Fault Controller (1/29/9_)
	m	WTC Car 6B Setup Parameters
	n	A.C.E. Elevator Co. Inc., Swift Futura, CEC Job No. 2670 car 6B 2WTC Velocity/Fault Controller (4/18/95)
	o	Schematic Drawings, 2WTC-A.C.E. Elevator (Shuttle Cars) Job No. 3172, Cars 12B, 13B (3/20/97)
4	VDA Studies on WTC Elevator Fleet	
	a	Elevator door study (12/16/99)

ITEM		
	b	Examination of 1 WTC elevators 18-23 (5/11/00)
	c	Examination of 1 WTC elevators 1A-5A & 8A-11A (8/21/00)
	d	Examination of 2 WTC elevators 57B-62B & 87-92 (8/8/00)
	e	Examination of 2 WTC elevators 24B-29B (8/2/00)
	f	Examination of 2 WTC elevators 42B-47B (7/12/00)
	g	Examination of 2 WTC elevators 51B-56B (7/12/00)
	h	Examination of 2 WTC elevators 63B-68B (8/21/00)
	i	Examination of 2 WTC elevators 81B-86B (8/2/00)
	.j	Examination of 2 WTC elevators 93B-98B (8/2/00)
	k	Examination of 1 WTC elevators 12A-17A (12/16/99)
	l	Examination of 1 WTC elevators 12A-17A (5/11/00)
	m	Examination of 2WTC elevators 1B-5B & 8B-11B (6/28/00)
	n	Examination of 2 WTC elevators 12B-17B & 18B-23B (8/21/00)
M	ELECTRICAL REPORTS	
	1	Operations Services Department Inspection & Safety Division evaluation of the electrical maintenance program at WTC (2/99)
	2	Burlington Engineering Co. Thermographic Scanning NE & SE Plaza buildings (3books) (8/8/96)
	3	Burlington Engineering Co. Thermographic Scanning Subgrade levels including "A" Tower (6/17/96)
	4	Burlington Engineering Co. Thermographic Scanning "B" Tower (2 books) (8/8/96)
	5	Burlington Engineering Co. Thermographic Scanning "A" Tower (8/8/96)
	6	Electrical Capacity Upgrades Summary
N	BLAST RELATED REPORTS/INFORMATION	

ITEM		
	1	WTC Explosion and Fire Environmental Investigation and Assesment Report
	2	Summary of Structural repairs as a result of February 26, 1993 Explosion (2 copies of 10 drawing sets)
	3	York Water Chiller System Post Blast Equipment Analysis
	4	Letter from Fire Department Attesting to Post-Bomb Adequacy of Life Safety Systems
	5	Description/Status of Fire System CADD
O	LIFE SAFETY CODE ANALYSIS (11/94)	
	1	ADA Transition Plan
	2	Contract WTC-799.56A Fire Safety Director Service 1,2,4 & 5 WTC
	3	Contract WTC-799.610 Maintenance of Office Space Security System Software at the WTC
	4	New Fire Alarm System description & status
P	TENANT CONSTRUCTION GUIDELINES	
	1	Tenant Construction Review Manual
	2	Fire Alarm Guidelines
	3	Electrical Communication
	4	HVAC, Plumbing & Fire Protection
	5	Architectural & Structural
	6	Pro Forma Applications
Q	MAPS & DRAWINGS	
	1	Tenant Location Plans / Space Book Plan
	2	Architectural Drawings of Property (10 CD-rom)
	3	Above-Grade Survey
	4	Detailed Retail Drawings
	5	Detailed Retail Drawings (4 CD-rom)
	6	CADD Drawings of the Subgrade

ITEM			
	7	Highly Illustrative Subgrade Drawings	
	8	Subgrade Drawings (4 CD-rom)	
	9	Parking Map	
	10	Damage Map Pertaining to the Acquisition of Certain Real Property by the PA for WTC	
	11	Base Building One-Line System Drawing	
	12	Stack Plans	
R	PUBLIC SPACE RENOVATION MASTER PLAN		
	1	Davis, Brody& Associates World Trade Center Master Plan	
	2	Renovation Development Proposal (LaSalle Partners)	
	3	Renovation Development Proposal (The O'Conner Group)	
	4	Renovation Development Proposal (LCOR/The Hahn Company)	
		a.	Volume 1: Development Team (2/1/95)
		b	Volume 2: Base Design Concept (2/1/95)
		c	Volume 3: Development, Management and Operating Proposal (2/1/95)
		d	Volume 4: Financial Proposal (2/1/95)
		e	Volume 5: Alternative Proposal (2/1/95)
		f	Volume 6: Design Concept, Retail Plan, and Events Presentation (2/16/95)
		g	Revised Proposal
	4	WTC Preliminary Study to Reduce Plaza Windiness	
	5	WTC Plaza Stone Site Investigation	
	6	Smoke Management Design Criteria	
	7	Life Safety Systems & Emergency Evacuation	
	8	Halcyon Report, Area Worker and Visitor Survey	
S	AGREEMENTS		
	1	Agreements/Memorandums of Understanding	

ITEM		
	a.	Union Agreements
	b	Power Authority of the State of New York Agreement
	c	Memorandum of Understanding ("MOU") with NYC Fire Department & Amendment
	d	MOU with NYC Building Department
	e	Agreement between the PA and NYC Pertaining to Certain Street Closings and a Change in the City's Waterfront Plan to Accommodate Certain Landfills being Created in Connection with the Development of WTC (6/67)
	f	Agreement between the PA and NYC Pertaining to Certain Street Closings in Connection with the Development fo WTC (1/68)
	g	Agreement between NYC, Fisher Liberty Co. and the PA Pertaining to the Liberty Street Pedestrian Bridge (8/76)
	h	Agreement between NYC and the PA Pertaining to the Liberty Street Underpass (5/12/80)
	i	Agreement between NYC and the PA Pertaining to the Dey Street Underpass (5/80)
	j	Settlement Agreement among NYC WTC7, and the PA Pertaining to the Vesey Street Deck (4/84)
T	LEGAL INFORMATION	
1	Pending Litigation Materials	
	a	Summons dated 11/10/99 with Dean Witter Reynolds Inc. against The Fund for Regional Development and Port Authority of New York and New Jersey (Index No. 605118/99)
	b	Answer dated 5/25/00 regarding Summons with Dean Witter Reynolds Inc. against The Fund for Regional Development and Port Authority of New York and New Jersey (Index No. 605118/99)
	c	Summons dated 1/7/00 with Guy Carpenter and Company Inc. against The Fund for Regional Development and Port Authority of New York and New Jersey (Index No. 600091/00), together with Complaint dated 12/29/99 attached thereto
2	Commonwealth Land Title Insurance Co. Documentation	

ITEM		
	a.	Title Commitment
	b	Copies of Recorded Easements and other Exceptions to Title
	c	Easement Agreement among PA, PATH, BPCD and BPCA (9/81) and Amendments thereto (2/82, 1/84)
	d	Letter from R. Gochfield, Dept. of City Planning, City of NY to H. Barr, PANYNJ re: Proposed Change in City Map for the WTC, with attached surveys
U	INTELLECTUAL PROPERTY INFORMATION	
	1	Schedule of Patents, Trademarks, Tradenames and Copyrights Held or Used and Documentation Relating to Related Claims
V	MISCELLANEOUS	
	1	Engineering Department Professional and Technical Service Firm Rosters for the Architectural, Electric, Environmental, Mechanical and Structural Disciplines
	2	World Trade Center Tenant Manual
	3	PA Comprehensive Annual Financial Report for the Year ended 12/31/99

ATTACHMENT 4

World Trade Center-Proposed 2001 Capital Plan

W. TRADE CENTER - PROPOSED 2001 CAPITAL F ROUGH BREAKDOWN BY BUILDING

($'s in thousands)

Proj Title	2001	Bldg 1	Bldg 2	Bldg 4	Bldg 5	Retail Mall	Subgrade	Central Sys
Electrical & HVAC Capacity Upgrade								
HVAC Distribution System Rehabilitation	1,000	400	400	100	100			
1 WTC 3d Zone Electrical & HVAC Capacity	1,000	1,000						
HVAC Control System/Smoke Mgmt	1,000					1,000		
HVAC Distribution Capacity Upgrade	2,500		2,500					
Freeze Protection Systems	1,000	1,000						
Plaza Bldg Electrical Capacity Upgrade	2,000			1,000	1,000			
New Fire Alarm System								
Fire Alarm System Phase 3 - PA Work	8,000	2,000	2,000	500	500		3,000	
Fire Alarm System Phase 3 - Tenant Reimb	250	100	100		50			
Other Building Systems Upgrades								
Operations Control Center	500							500
Tenant Standby Power	2,000							2000
Substation Ground Fault Protection	500							500
Antenna & Mast Rehabilitation Projects	500	500						
Building Mgmt/Energy Mgmt Systems	500							500
Common Area Improvement Programs								
Public Space Code Improvements	2,500					2,500		
Public Space Infrastructure Improvements	3,000					3,000		
Mall Circulation Improvements Phase 2	500					500		
Priority Customer Service Improvements	4,000	500	500			3,000		
Subgrade Rehabilitation Programs								
Subgrade Slab Rehabilitation Phase 1	10,000						10,000	
Subgrade Slab Rehabilitation Phase 2	500						500	
Subgrade Code Upgrade Projects	500						500	

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W TRADE CENTER - PROPOSED 2001 CAPITAL F - ROUGH BREAKDOWN BY BUILDING

($'s in thousands)

Proj Title	2001	Bldg 1	Bldg 2	Bldg 4	Bldg 5	Retail Mall	Subgrade	Central Sys
Security Programs								
Permanent Security Project	500							500
Office Space Security System	500							500
Security Modernization Projects	5,000							5,000
Elevator and Escalator Modernization Programs								
Elevator Control Modernization - Tower 1	3,500	3,500						
Elevator Control Modernization - Tower 2	3,500		3,500					
Plaza Bldg Elevator Control Modernization	500			250	250			
Asbestos Abatement Shuttle Shafts	500	500						
Elevator Disconnect Switches	1,000	500	500					
Tenant Space Prep/Landlord Work Projects								
Lease Obligated Capitel Work	2,000	750	750			500		
Multi-Tenant Floor Corridor & Restrm Rehab	3,000	1,000	1,000			1,000		
Building Infrastructure Rehabilitation Programs								
Priority Capital Major Work Projects	500							
Capital Major Work Projects	5,000	1,000	1,000					2,000
Other Asbestos Abatement	500		250	250				
ADA Projects	250					125	125	
GRAND TOTAL	68,000	12,750	12,500	2,100	1,900	11,625	14,125	11,500

Draft - 11/3/00

ATTACHMENT 5

World Trade Center-Proposed 2002-2005 Capital Plan

WORLD TRADE CENTER - PROPOSED 2002-2005 CAPITAL PLAN - ROUGH BREAKDOWN BY BUILDING

($'s in thousands)

Proj Title	2002	2003	2004	2005	2002-2005	Bldg 1	Bldg 2	Bldg 4	Bldg 5	Retail Mall	Subgrade	Central Sys
Electrical & HVAC Capacity Upgrade												
HVAC Control System/Smoke Mgmt	2,000	3,000	5,000	5,000	15,000	2,500	2,500					10,000
HVAC Distribution Capacity Upgrade	2,000	2,000	3,000	3,000	10,000	2,000	4,000					4,000
Freeze Protection Systems	1,000	1,000	1,000	1,000	4,000	1,000	3,000					
Plaza Bldg Electrical Capacity Upgrede	2,000	2,000	2,000	2,000	8,000			3,000	3,000			2,000
New Fire Alarm System												
Fire Alarm System Phase 3 - PA Work	8,000	4,000	0	0	12,000						10,000	2,000
Fire Alarm System Phase 3 - Tenant Reimb	250	0	0	0	250	100	100	50				
Other Building Systems Upgrades												
Operations Control Center	500	500	500	500	2,000							2,000
Tenant Standby Power	2,000	2,000	2,000	2,000	8,000							8,000
Antenna & Mast Rehabilitation Projects	500	500	500	500	2,000	2,000						
Building Mgmt/Energy Mgmt Systems	1,000	1,000	2,500	2,500	7,000							7,000
Common Area Improvement Programs												
Public Space Code Improvements	2,000	2,000	2,000	2,000	8,000					8,000		
Public Space Infrastructure Improvements	5,000	5,000	5,000	5,000	20,000					20,000		
Mall Circulation Improvements Phase 2	2,000	5,000	6,000	5,000	18,000					18,000		
Priority Customer Service Improvements	3,000	3,000	3,000	3,000	12,000	2,000	2,000	1,000	1,000	6,000		
Subgrade Rehabilitation Programs												
Subgrade Slab Rehabililation Phase 1	6,000	0	0	0	6,000						6,000	
Subgrade Slab Rehabilitation Phase 2	1,000	5,000	5,000	5,000	18,000						16,000	
Subgrade Code Upgrade Projects	1,000	1,000	1,000	1,000	4,000						4,000	

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WORLD TRADE CENTER - PROPOSED 2002-2005 CAPITAL [illegible]N - ROUGH BREAKDOWN BY BUILDING

($'s in thousands)

Proj Title	2002	2003	2004	2005	2002-2005	Bldg 1	Bldg 2	Bldg 4	Bldg 5	Retail Mall	Subgrade	Central Sys
Security Programs												
Office Space Security System	250	250	250	250	1,000	400	400	100	100			
Security Modernization Projects	3,000	3,000	3,000	3,000	12,000							12,000
Elevator and Escalator Modernization Programs												
Elevator Control Modernizetion - Tower 1	3,500	3,500	3,500	3,000	13,500	13,500						
Elevator Control Modernizetion - Tower 2	3,500	3,500	3,500	3,000	13,500		13,500					
Asbestos Abatement Shuttle Shafts	500	500	500	500	2,000	1,500	500					
Elevator Disconnect Switches	500	0	0	0	500	250	250					
Tenant Space Prep/Landlord Work Projects												
Lease Obligated Capital Work	2,000	3,000	3,000	3,000	11,000	4,000	4,000	1,000	1,000	1,000		
Multi-Tenant Floor Corridor & Restrm Rehab	3,000	3,000	3,000	2,000	11,000	4,500	4,500	1,000	1,000			
Building Infrastructure Rehabilitation Programs												
Priority Capital Major Work Projects	500	500	500	500	2,000							2,000
Capital Major Work Projects	5,000	5,000	5,000	5,000	20,000	2,000	2,000	500	500			15,000
Other Asbestos Abatement	500	500	500	500	2,000	600	600	150	150		500	
ADA Projects	250	250	250	250	1,000	100	100			800		
GRAND TOTAL	61,750	60,000	61,500	58,500	241,750	36,450	37,450	6,800	6,750	53,800	36,500	64,000

Draft - 11/3/00

ATTACHMENT 6

R.W. Crandlemere & Associates Environmental Site Assessment Phase I Report
(Separate binder)

ATTACHMENT 7

BOCA Group International, Overall Observation

BOCA GROUP
INTERNATIONAL, INC.
VERTICAL TRANSPORTATION CONSULTING

December 5, 2000

Mr. Robert Weiland
Merritt & Harris
110 East 42nd Street
Suite 1200
New York, NY 10017-5685

RE: **ONE, TWO, FOUR & FIVE WORLD TRADE CENTER**
OVERALL OBSERVATION

Dear Mr. Weiland:

Our engineers performed a visual observation and reviewed contracts and documentation, as listed below, of the elevators at the above referenced projects. The elevators and escalators were observed on a "specimen sample" basis. A few units from each building were observed, and these were broken down into units where the "complete modernization" was finished and units where modernization had not been performed as of November 1, 2000. According to the specifications, the modernization is being performed in two phases, the Overlay Modernization Phase and Complete Modernization Phase.

List Of Documents Reviewed

We also reviewed a few documents at the Port Authority Vertical Transportation Office. The following is a list of the documents we observed:

1. World Trade Center Property Book
2. Offering Memo
3. The Port Authority of NY and NJ
    - The World Trade Center Contract WTC – 845-071 "Modernization of Elevators, Dumbwaiters and Escalators @ One World Trade Center" March 1994
    - The World Trade Center Contract WTC – 838-071 "Modernization of Elevators and Escalators @ Four and Five World Trade Center" September 1993
    - The World Trade Center Contract WTC – 846-071 "Modernization of Elevators and Escalators @ Two World Trade Center" March 1994

- Maintenance Contract for World Trade Center - 799.700 Maintenance.

4. VDA Maintenance Surveys
   i. dated June 14, 2000 (Elevators 1A – 5A, & 8A – 11A
   ii. dated August 2, 2000 (WTC tower "B" Local Elevator nos. 63, 64,65,66,67 & 68)
   iii. dated August 21, 2000 (Elevators 81B – 86B)
   iv. dated October 16, 2000 (Elevators 75B – 85B in Two WTC)

5. Correspondence dated October 17, 2000 from the Port Authority to ACE Elevator Company.

6. Monthly callback summaries on elevators with greater than two outages (April, May, June, August, September and November, 1999; January –May 2000 and July –October 2000) for One World Trade Center and Two World Trade Center.

7. OCC DECK Reports dated 10/16/00 and 11/1/00.

FORM OF REPORT:

Following this overall observation, is a summary of the scope of work included in the modernization of the elevators located within the World Trade Center.

A status of the elevator modernization program follows the overall observations.
The sub-grade units are listed immediately following the status report, which is followed by a listing of the tenant units and the retail units that we observed in the layout drawings.

A section discussing the current maintenance being performed follows the previously described sections.

Detailed reports on the individual buildings follow the status of the elevator modernization. These reports describe the equipment that we observed and also list information that we gleaned from the documents that we reviewed.

At the end of each section are the traffic calculations and analyses for the various buildings. Please note that these calculations do not include any of the tenant owned and operated elevators

The following sections include reports for the individual buildings.

GENERAL NOTES

The four buildings have a total of 238 elevators 126 of them have been modernized, 8 already in progress and 104 not yet started but scheduled for a future date. Most of the modernized elevators have SCR Drives with CEC Swift Futura Controllers, door operators retrofitted with solid state controls to interface with the new controllers all

giving the elevator better service and a better quality ride. All passenger elevators have had cab refurbishing, all but two are ADA compliant.

Due to a previous elevator incident at Two World Trade Center elevators 18-23B were excluded from our inspection.

Five tenant owned and operated elevators were not observed and form part of this report by reference only.

Upon inspection of the hoistway we observed the hoistway doors are fire rated with UL certification labels. To provide a statement on the hoistway walls being fire rated, a sampling would be necessary. This was not performed during our inspection which was of a visual nature.

All Escalators have been modernized with start/stop switch, comb plate switch, demarcation lights, caution signs, controlled descent devices, remote monitoring system, Carl White device (new for every device).

The PATH Escalators are excluded from the scope of this report.

SPECIAL ELEVATOR FEATURES

Track and saddle inserts have been installed predominately in tower shuttles and D Bank reducing friction between saddle and gibs minimizing stack effect problems on elevators.

Buildings One World Trade Center and Two World Trade Center provide a warning device, located on the 108 Floor, which rates the wind sway that automatically reduces the speed of the elevators to prevent possible damages. Accordingly, the shuttle elevators have the ability to have speed reduced automatically from 1600 Feet Per Minute to 1000 Feet Per Minute whenever strong wind conditions are observed and a warning system is activated as described below.

In buildings One World Trade Center and Two World Trade Center, elevators Nos. 14 and 15 have hoistway wall roller followers, which have proven to be successful in minimizing wall erosion due to rope contact. The followers are installed on all the high-rise shuttles, elevator Nos. 6 and 7 in each tower.

In all buildings the elevators can be recalled down to their respective lobbies via the elevator start consoles.

We hope you find this report useful in the due diligence analysis of the aforementioned properties. If you have any questions, please call the undersigned at (212) 983-7010

Sincerely,

BOCA Group International, Inc.,

Vish Shetty

Elevator Modernization – Summary of Scope of Work
(As of 11/1/2000)

Shuttle Elevators

Removal of existing equipment, designing, fabricating, delivering and installing an operating overlay prior to ordering full modernization.

Removal of existing equipment, designing, fabricating, delivering and installing a complete modernized elevator.

Remove existing motor generator, design, deliver and install new silicone controlled rectifier (SCR) power conversion units.

Design, fabricate, deliver and install revised emergency power operation line starter selection.

Removal of existing hall call fixture and designing, fabricating, delivering, and installing of a new hall call fixture.

Removal of existing hall lanterns and designing, fabricating, delivering and installing of new hall lanterns.

Removal of existing jamb markers and designing, fabricating, delivering and installing of new jamb markers.

Design, fabricate, deliver and install new car to lobby (CTL) key switch with updated wiring changes.

Local Elevators

Removal of existing equipment, designing, fabricating, delivering and installing an operating overlay prior to ordering full modernization.

Removal of existing equipment, designing, fabricating, delivering and installing a complete modernized elevator including SCR drives and microprocessor based controllers.

Design, fabricate, deliver and install new car to lobby (CTL) key switch with updated wiring changes.

Design, fabricate, deliver and install revised emergency power operation line starter selection.

Removal of existing hall call fixture and designing, fabricating, delivering and installing of a new hall call fixture.

Removal of existing hall lanterns and designing, fabricating, delivering and installing of new hall lanterns.

Removal of existing jamb markers and designing, fabricating, delivering and installing of new jamb markers.

Freight Elevators

Removal of existing equipment, designing, fabricating, delivering and installing an operating overlay prior to ordering full modernization.

Removal of existing equipment, designing, fabricating, delivering and installing a complete modernized elevator including SCR drives and microprocessor based controllers.

Removal of existing door protective devices and designing, fabricating, delivering and installing of door protective devices.

Provide new freight elevator hall lanterns at each landing served. This includes designing, fabricating, delivering and installing new hall lanterns.

Removal of existing jamb markers and designing, fabricating, delivering and installing of new jamb markers.

Status of WTC Elevator Modernization Program

(as of 11/1/2000)

1 WTC

	Complete	In Progress	Future
Local	56	3	13
Low-Rise	0	0	8
High-Rise	6	0	7
Freight	2	0	4

2 WTC

	Complete	In Progress	Future
Local	37	2	33
Low-Rise	0	0	8
High-Rise	6	2	5
Freight	1	0	5

4 WTC

	Complete	In Progress	Future
Local	11	0	1
Freight	0	0	2

5 WTC

	Complete	In Progress	Future
Local	7	1	1
Freight	0	0	2

SUBGRADE

Complete	In Progress	Future
0	0	15

SUB-GRADE ELEVATORS

ELEVATORS SERVING SUB-GRADE ONLY

ELEVATOR	FLOORS SERVED
K2	Front: B1 Rear: B4, B5, B6
K1	1, B1
FE5	B1-B3
FE8	43-44
J4	1, B1
FE1	B2, B1, 1
FE2	B2, B1, 1
FE3	B1, 1, 2-9
FE4	B1, 1, 2-9

ELEVATORS SERVING SUB-GRADE IN ADDITION TO OTHER FLOORS

ONE WORLD TRADE CENTER

ELEVATOR NUMBERS 50, 7, 49, 17, 48, 5, ARMOR CAR, ALL "J" CARS, 36, 41, 42, 47, 35, 30, 29, 24.

TWO WORLD TRADE CENTER

ELEVATOR NUMBERS 50, 7, 49, 17, 48, 5, ARMOR CAR, ALL "K" CARS, 36, 41, 42, 47, 35, 30, 29, 24.

TENANT ELEVATORS AND ESCALATORS

FIVE WORLD TRADE CENTER

UNIT TYPE	UNIT NUMBER	FLOORS SERVED	# OF UNITS
ESCALATOR	CSE 1 AND CSE 2	2 TO 3AND 3 TO 2	2
ESCALATOR	NONE	1 TO 2, 2-3 AND 3-2	3
HYDRAULIC ELEVATOR	BORDERS BOOK STORE	1,2,3	1

FOUR WORLD TRADE CENTER

UNIT TYPE	UNIT NUMBER	FLOORS SERVED	# OF UNITS
ELEVATOR	1 AND 2	1, 3, 4, 5 6	2
ELEVATOR	SWISS BANK	NOT AVAILABLE	1

RETAIL ESCALATORS

We have been informed by the Vertical Transportation Department of the Port Authority of NY and NJ that these units incur unusually high maintenance costs due to high traffic volume and also due to the fact that these escalators are used to transport handcarts and other wheeled carriages.

ONE WORLD TRADE CENTER

NONE

TWO WORLD TRADE CENTER

NONE

FOUR WORLD TRADE CENTER

ESCALATORS NEAR LIBERTY STREET BETWEEN HSBC ATM AND NEWS STANDS (2 UNITS) (E14 AND E15)

ESCALATORS BETWEEN AU BON PAIN (E17 AND E18), VICTORIA'S SECRET AND BATH AND BODY WORKS

FIVE WORLD TRADE CENTER

CONCOURSE TO PLAZA (E19 AND E20)

ESCALATORS BETWEEN NINE WEST AND TOURNEAU STORES (2 UNITS) (E1 AND E2)

ESCALATORS TO SIX WORLD TRADE CENTER NEXT TO CHOICE COURIER (2 UNITS)

ELEVATOR MAINTENANCE

We performed a visual inspection of the 21 pre-selected elevators and a few escalators in buildings One, Two, Four, and Five World Trade Center, we have gathered that the equipment has to be closely monitored by the Vertical Transportation Department of the World Trade Department. We have also reviewed maintenance evaluation reports submitted by an independent third party based upon their field observations. These reports indicate deficiency items mostly related to house keeping, some of which remain to be corrected. The indications on the third party reports in reference to the preventive maintenance practices range from "acceptable" to "marginally acceptable" with "definite room for improvement in the area of housekeeping". Nevertheless, it appears from the correspondence we observed and during our general discussions that a great deal of close monitoring and follow up from the Vertical Transportation Department is required for the elevator maintenance company to respond to schedule requests as well as perform preventive maintenance. We understand that the elevator company does not inform the PA about any past problems or future repairs that need to be scheduled as a result of which the problems persist.

Additionally, we reviewed the maintenance callback sheets listed previously after which we performed a visual inspection of additional machine rooms in One World Trade Center and Two World Trade Center. This field visit revealed a large amount of rouged cables and bad machine bearings. The rouged cables are contributing largely to the amount of dust and dirt in the machine room, on the machine room equipment and secondary equipment. This condition will most likely cause contact failures, electrical shorts and other potential hazards to the equipment and its workers. There was a significant amount of bad machine bearings observed which are causing noise and vibration in the machines. If this is not corrected soon more serious damage will be caused to the hoist machines.

It was also noted that a few elevators had temporary jumpers on the controller, which is not a generally accepted practice in the elevator industry and could be potentially dangerous.

The following section describes some of the significant deficiencies that we observed all of which are covered under the full-service maintenance contract in effect.

SIGNIFICANT MAINTENANCE ITEMS

ONE WORLD TRADE CENTER

<u>Major Maintenance Items:</u>

1. Excessive dust in all machine rooms observed
2. Rouged cables on Elevators 74, 1, 4, 66, 58, and 60
3. Cables with breaks on Elevators 63 and 64

4. Defective machine bearings on Elevators 72, 46 and 61

Other Maintenance Items:

Elevators Nos. 63 - 68:
Elevator No. 63 - Many breaks in cables.
Elevator No. 64 - Many breaks in cables.
Elevator No. 65 - Relevels many times, Cables are filthy
Elevator No. 66 - Slightly rouging of hoist cables.
Elevator No. 68 - Excessive carbon dust in hoist motor.

Elevators Nos. 57 - 62:
Elevator No. 58 - Cables have excessive rouging - all in machine.
Elevator No. 59 - Carbon dust excessive in hoist machine.
Elevator No. 60 - Rouge in cables
Elevator No. 61 - Vibration in main bearing and excessive carbon dust in machine.

Elevators Nos. 49, 69 - 74:
Elevator No. 49 - Four temporary jumpers on controller. Large amount of dust in hoist machine and motor.
Elevator No. 69 - Excessive rouge dust in hoist machine.
Elevator No. 72 - Bad main bearing - whole machine rocks.
Elevator No. 73 - Rouge dust around and in internal brake.
Elevator No. 74 - Excessive cable rouge - all over and in machine.
Rouge on Machine room floor.

Elevator No. 16 - Cable has broken lay. Secondary rouged cables - rouge all over machine room. We were informed that one of the hoist cables broke, started untwisting and came in contact with metal causing a spark, which started a fire in secondary. Elevator shut down for repairs.

Elevator No. 74 - Cables rouged - Rouge all over machine room.

Elevator No. 72 - Bad main bearing - machine rocks.

Elevator No. 1 - Excessive cable rouging condition and excessive oil on brake pads.

Elevator No. 4 - Excessive cable rouge.

Elevator No. 46 - Bad main bearing and cables are rouged.

TWO WORLD TRADE CENTER

Major Maintenance Items:

1. Rouged cables on Elevators 8, 9, 63-68 ,72, 2, 7, K5, 26 and 28.
2. Bad machine bearings on Elevators 11, 56, 73 and 26
2. Excessive dust in machine room.

Other Maintenance Items:

Elevators Nos. 1-5:
No. 1 Elevator - Carbon dust in hoist motor - cables rouged all over. Oil on brake pads.
No. 2 Elevator - Cables rouged all over - Pie Plate Selector very noisy.

Elevators Nos. 6, 7, 50 and 99: Carbon dust in all hoist motors
No. 6 Elevator - Oil on brake pads.
No. 7 Elevator - Rouged cables caused excessive rouge deposits all over machine.
No. 49 Elevator - Jumper on controller, rouge all in controller, carbon dust excess in hoist motor.

Elevators Nos. 12 - 17: Dust in all machines
Elevator No. 16 - Excess carbon dust in hoist motor & rouge on drive sheaves.
Elevator No. 14 - Car oil seepage in main bearing sheave side

Elevators Nos. K3 - K5:
Elevator No. K5 - Rouge on cables - Not bad.

Elevators Nos. 24-29:
Elevator No. 26 - Bad main bearing and cable rouging.
Elevator No. 28 - Cable have rouging - rouge in hoist machine.
Elevator No. 27 - Rouge dust in hoist machine.

Low Rise Shuttles
Elevator No. 8B - Cables rouged causing rouge all over machine room.
Elevator No. 9B - Cables rouged causing rouge all over machine room.
Elevator No. 10B - Low Brushes and rouge all over machine room.
Elevator No. 11B - Bad main bearing and rouge all over machine room.

Elevators Nos. 51 - 56:
Elevator No. 56 - Bad main bearing

Elevators Nos. 57 - 62:
Elevator No. 62 – Full size hoist motor brushes are not in contact with commutator. Many brushes are low.

Elevators Nos. 63 - 68:
Elevator No. 63 - Cables rouged.
Elevator No. 64 - Cables rouged.
Elevator No. 65 - Cables rouged.
Elevator No. 66 - Cables rouged causing rouge all over hoist machine.
Elevator No. 67 - Cables rouged causing rouge all over hoist machine.
Elevator No. 68 - Cables rouged all over, and oil leak in main bearing.

Secondary – There are thick amounts of rouge all over. Generator copper shavings inside and carbon excessive

Elevators Nos. 69 - 74:
Elevator No. 72 - Car cables rouged; rouge all over machine room.
Elevator No. 73 - Main bearing real bad, whole machine shakes.

MAINTENANCE ITEMS

The two OCC Deck reports show many long outstanding maintenance items, some dating as far back as March 2000. This is indicative of poor response from the elevator company.

CALLBACKS

The following charts summarize the callback information that was provided to us as indicated in item #6 under the list of documents reviewed.

A review of the charts will indicate an excessive amount of callbacks on both old units and new units. Although all callbacks may not be attributed to poor maintenance, they are a good indicator of preventive maintenance and while difficult to eliminate totally, can be minimized with a good maintenance program in place. The excessive callbacks shown on the charts for some units are especially unacceptable on the modernized elevators. (The average number of callbacks (>2 only) for new units (for 15 months) is 5.75 for One World Trade Center and 3.45 for Two World Trade Center). As per one of the major elevator manufacturers and installers, an acceptable shutdown frequency for a controller related problem would be one per year per elevator.

ELEVATORS WITH >2 CALLBACKS

MONTH	ONE WORLD TRADE CENTER			TWO WORLD TRADE CENTER		
	OLD UNITS	NEW UNITS	TOTAL	OLD UNITS	NEW UNITS	TOTAL
Apr-99	73	9	**82**	48	3	**51**
May-99	45	13	**58**	58	14	**72**
Jun-99	58	22	**80**	34	13	**47**
Aug-99	29	20	**49**	17	10	**27**
Sep-99	20	29	**49**	36	14	**50**
Nov-99	34	46	**80**	40	14	**54**
Jan-00	21	9	**30**	32	10	**42**
Feb-00	34	15	**49**	18	16	**34**
Mar-00	34	37	**71**	51	10	**61**
Apr-00	16	29	**45**	31	18	**49**
May-00	30	25	**55**	29	6	**35**
Jul-00	25	37	**62**	29	6	**35**
Aug-00	25	14	**39**	29	7	**36**
Sep-00	6	21	**27**	21	4	**25**
Oct-00	17	42	**59**	44	7	**51**
TOTAL	**467**	**368**	**835**	**517**	**152**	**669**

TOTAL UNITS WITH >2 CALLBACKS		
	ONE WORLD TRADE CENTER	TWO WORLD TRADE CENTER
Apr-99	15	10
May-99	11	14
Jun-99	18	11
Aug-99	11	7
Sep-99	8	11
Nov-99	17	14
Jan-00	9	10
Feb-00	13	7
Mar-00	17	12
Apr-00	8	13
May-00	13	10
Jul-00	10	12
Aug-00	11	8
Sep-00	7	5
Oct-00	13	11

SECTION V – EXISTING PROPERTY DESCRIPTIONS & CONDITIONS

A. Overall Project

Building Type	Commercial Office Building
Built-Circa	1971
Certificate of Occupancy	A Certificate of Occupancy has not been issued by the City of New York because property owned by the Port Authority is not subject to the Building Code of the City of New York. We have observed "Permits to Use or Occupy" issued by the Port Authority for specific work, notably the October 10, 1997, Permit issued following completion of repairs following the 1993 bombing, but the Port Authority did not routinely issue the equivalent of a Base Building Occupancy Certificate until January 1992. In addition, in December 1995, the Port Authority (PA) started an optional "Self Certification" program for alteration work by tenants. The PA has issued "Consent to Occupy" for specific work under this program.
Story Height	12' 0" typical office story 14' 0" at sky lobbies 14' at 43rd and 16' at 67th floors 28' (2-story) at mechanical equipment rooms (MER)
Number of Stories	110 stories plus 6-subgrade levels
Building Height	The overall building height from lobby level to the roof level is reported at 1,368'.
Total Sq. Ft. (Bldg. Area)	42, 900 gsf (gross sq. ft.) footprint calculated 4,761,416 gsf (1968 REBNY) 4,468,634 gsf (as remeasured by REBNY 1987 Guideline 4,358,604 rsf May 31, 2000 (Rent Roll Sq. Ft.)

General Breakdown of Floor Uses

Floors	Predominate Uses
110	Elevator Machine Room, Tank Rooms, Broadcasters
108-109	Mechanical Equipment, Elevator Machine Room
106-107	Restaurant (Windows on the World)
79-105	Offices
78	Sky lobby Floor, Offices
77	Offices, Elevator Pits
75-76	Mechanical Equipment
45-74	Offices
44	Sky Lobby, PA Kitchen, Offices
43	Port Authority Cafeteria, Elevator Pits
41-42	Mechanical Equipment, Elevator Machine Rooms
9-40	Offices
7-8	Mechanical Equipment
3-6	Core Area, Locker Rooms
Plaza	Main Entrance Mezzanine from the Plaza
Lobby	Main Entrance Lobby from Concourse
B-1	Truck Dock Access, Storage and Maintenance Subcontractors, Elevator Pits
B-2	Storage and Maintenance Subcontractors, Elevator Pits, Parking Access
B-3	Storage and Maintenance Subcontractors, Parking Access
B-4	Storage and Maintenance Subcontractors, Parking Access
B-5	Mechanical Equipment
B-6	Mechanical Equipment, Elevator Machine Room

Special Features

The building is the tallest building in New York City and among the tallest in the World. The roof contains the main antenna for all, but 1, New York City television broadcasting stations. Office space is column free, with up to 60' spans between the core and facade. The Windows on the World restaurant occupying the 107th story provides spectacular views of New York City and its harbor, including overlooking the Statue of Liberty. This facility has 2 restaurants, and 4 banquet rooms. Enclosed connections to the World Financial Center and an on-site Marriott Hotel are provided.

Design Team

Architects	Minoru Yamasaki & Associates Emory Roth & Sons, P.C.
Slurry Wall	Port Authority
Structural Engineer	Skilling-Helle-Christiansen-Robertson
Mechanical Engineer	Jaros Baum & Bolles
Electrical Engineer	Joseph Loring & Associates

Recent Renovations

Sprinkler installation for LL 5/73 compliance

Fire alarm system modernization

Approximately 65% elevator system modernization including cabs, controllers, SCRs, ADA control panels.

Electric Power Upgrade -1999

Chilled water risers

Condenser water upgrade

B. Project Condition

Overview

The building maintenance is supervised by the Port Authority who retains a service contractor (ABM) to perform routine and special maintenance of equipment in common areas through a consolidated performance base contract. The Port Authority retains consultants to prepare evaluation reports on the major systems in the building.

Structure

Where they could be seen, the building's structural elements appeared free from signs of distress, deterioration, or building settlement. Structural Integrity Inspections (SII) have been performed by Leslie E Robertson Associates (LERA) and other engineering firms on many of the structural components of all the buildings in the World Trade Center. These SII reports are available in the Data Room. Deficiencies typically noted are rusting conditions in the steel columns in the elevator shafts, missing fireproofing, and occasional floor coring damage.

LERA recommends that the analysis of wind acceleration measurements be continued to monitor the dynamic behavior of the structure. They note that the 30-year-old visco-elastic dampers on the floor open web trusses have a finite life and must continue be monitored.

Visco-elastic dampers located at each floor joist at the connection to the perimeter columns dampen the sway motion. Sample dampers are tested every 5 years, most recently in 1996. It is reported that approximately 12 dampers are kept in stock for replacement.

Building Exterior

The building facade appears in good condition with no reported leaks. The facade is regularly inspected and repaired on an on-going 5-year cycle, with 10% of facade monitored by LERA to insure quality control. Structural Integrity Inspection reports are issued annually to the Port Authority. Recent SII reports note that the window gasketing is starting to exhibit age related deterioration. Wet sealing (sealant placed over gasket) is anticipated within 10 years.

The clear lacquer-coated anodized aluminum column covers exhibit finish color variations between panels.

Roofs

The main roof is the original membrane (reportedly asphalt felt built-up system) and is protected by 2" of rigid insulation and a 5" concrete overlay. The concrete topping is displaying age- and exposure-related deterioration, and a top coating is anticipated within the next 5 years.

Interiors

Multi-tenant floor common area finishes are typically average quality and are adequately maintained. Corridor carpets are reportedly 2 years old. Elevator vestibules are good durable quality. Most corridors have concealed spline acoustic ceiling tiles and many are displaying age- and usage-related wear, and replacement should be anticipated. Most toilet rooms are original durable finishes, with localized repairs for cracked tile or damaged tile required as ordinary maintenance. A capital program was initiated to upgrade multi-tenanted corridors and toilet rooms. Approximately 6 floors have been completed.

The 3 stair exit shafts typically display age- and usage-related wear and require floor repainting. Photo-luminescent paint stripes in stairs should be retained. The nosings on Stair B (wide stair) are bent outward in isolated locations and require repair. This condition occurs in both Towers.

Mechanical equipment floors (108, 41, B-6) require floor repainting, which is planned under the PA's Spit and Polish Program.

Vertical Transportation

The elevators appear adequately designed and are maintained under service contract. Passenger cabs were recently renovated, including cab interiors, ADA accessible front panels, and non-contact cab door safety edges. Escalators have been modernized with start/stop switches, comb plate switches, demarcation lights, caution signs, controlled descent devices, and remote monitoring systems.

Approximately 65% of the elevator equipment has been modernized with another 3% in progress. The remaining equipment has exceeded its functional useful life expectancy and continuing modernization is planned over the next few years (2004).

HVAC

The mechanical systems are adequately designed, using brand-name equipment, which provides adequate cooling for the office areas. To allow for the expanded substations in the 41st and 75th floor MERs, 4 AHUs were removed and new AHUs were installed. The original freeze protection system for the AHUs and reheat system for the heating hot water system have been abandoned in place, and consideration should be given to removal of the equipment for these systems. On the 108th MER, as a result of year-round cooling demands, a new freeze protection system has been installed. This system includes 2 circulating pumps and a heat exchanger that will circulate chilled water to all of the AHUs in this MER, instead of each AHU having its own pump. The same work will be performed in the remaining MERs over the next 5 years. The equipment has been well maintained, nearly all of the equipment is original (30 years old), and has or will exceed its published service life over the next 10 years, and replacement should be anticipated. A recent capital program to update the HVAC air-handling equipment has effectively increased the anticipated service life of the equipment. Equipment or component maintenance and repair is performed as part of the ABM service contract.

Plumbing

The plumbing systems appear to be in generally good condition, and are reportedly functioning satisfactorily. There have recently been problems with the failure of water hammer arrestors and leaks (see the Executive Summary). Although in operation, replacement of pumps, and water heaters should be anticipated over the next 10 years. Equipment or component maintenance and repair are performed as part of the ABM service contract.

Electrical

An adequate 10 watts/sq. ft. is provided from the 25th floor through the 105th floor. Six-watts/sq. ft. is available in the remaining areas of this Tower.

Life Safety

The life safety systems appear to meet code requirements for modern hi-rise office buildings. The building has completed sprinkler installation for compliance with LL5/73, and is in process of installing a Class "E" fire alarm system. Signoffs from the Port Authority should be furnished.

Property Maintenance

The in-house maintenance is performed by a service firm retained by the Port Authority. Electrical, HVAC, and general maintenance is performed under the terms of a performance based service contract by ABM Engineering with oversight by the Port Authority World Trade Department's Building Services Management Division. In general, maintenance appears to be adequate. Housekeeping deficiencies were noted in stairwells and service areas. Some mechanical equipment room floor slabs require refinishing. Exposed rooftop ferrous metals require better maintenance.

Accessibility

The building's entrances and elevators (except Express Elevators 18 and 19) are substantially ADA compliant. Toilet rooms on multi-tenanted floors are typically (75% estimated) non-ADA compliant. A program of upgrading was started 2 years ago. ADA compliance on most full tenant floors is reportedly the responsibility of the tenant under terms of the lease.

Violation Status

As stated in the Offering Memorandum, "The Port Authority is a municipal corporate instrumentality and political subdivision of the States of New York and New Jersey which provides transportation, terminal, and other facilities of commerce within the Port District. As such, in connection with the Transaction, the PA will continue to maintain exclusive jurisdiction with respect to certain administrative and governmental matters involving the Complex, including compliance with building, environmental, fire and health codes." The New York City Department of Buildings has indicated that they do not maintain any records of violations for this property. A request for a Property Profile Overview for this block and lot number yields no records. The Fire Department provides normal fire fighting and a life safety service to the facility. A Memorandum of Understanding exists between the Port Authority and the Fire Department in which the Fire Department performs regular inspections and directly notifies the Port Authority Fire and Life Safety group of deficiencies to be corrected. Under a protocol with the New York City Fire Department, Port Authority Police personnel investigate certain fire alarms at the World Trade Center rather than transmitting such alarms to the New York City Fire Department.

C. Site

Site information for all of the buildings is included within the Executive Summary section.

D. Building Description

1. Structure

Foundation

The foundation of 1 WTC is situated within a common 6-level deep (70') subgrade space (2 WTC, 3 WTC, 6 WTC), which is enclosed by 3' thick concrete cut-off walls installed by the slurry trench method.

Drawings indicate the Tower foundation under the building's columns consists of steel bearing plates and 2-way steel grillage placed on concrete leveling fill bearing on 40 tsf capacity bed rock, located under the B-6 cellar level.

Slab-on-Grade

Level B-6 floor slabs are concrete slab-on-grade placed over porous fill on bedrock.

Superstructure

The building structure is steel built-up box-shaped columns at the exterior perimeter, and box-shaped or wide-flange columns at the central core area. Columns are 10' o/c at the base and tree outward into 3' 4" spacing up the full height of the building. Structural steel spandrel girders are installed between the columns. Doubled, 29" deep, open web joists spaced at 6' 8" o/c span from core to the exterior columns. Exterior columns between the open web joists are stabilized by 2 diagonal angle braces cast into the slab and attached to the adjacent trusses.

The Tower columns, girder, and floor joists are fire protected with spray-on fireproofing. Basement area steel girders and beams are typically encased in concrete.

The roof structure is referred to as The Crown and it serves to stabilize the exterior columns. It is formed with structural steel trusses for rigidity. Identified lead paint may require future abatement. The interior section of the roof slopes up above the perimeter roof level.

Lateral wind loads are resisted by the 207' square hollow tube effect created by the rigidity of the closely spaced exterior columns and rigid spandrel girders connecting the columns. Wind sway movements on the top story reportedly approach 3'. Visco-elastic dampers located at each floor joist at the connection to the perimeter columns dampen the sway motion. Sample dampers are tested every 5 years. Replacements are available in-house.

Floors

The typical office story floor has 1 1/2" deep metal form deck, with cellular raceways for electrical and communication wiring, and 4" lightweight concrete slab with steel reinforcement. The typical floor core area, and the basement slabs are 4 1/2" normal weight reinforced concrete slab acting compositely with beams and girders.

The roof is reinforced concrete slab.

Other

There is a 360' television transmission mast on the roof of Tower I. The transmission mast is guy-wired into the rigid truss framed roof. The mast is automatically heated from the building steam system to avoid low temperature brittleness. Special maintenance procedures are required.

Design Loads

The following live loads are noted on the drawings or in the Structural Integrity Reports or PA Design Guidelines:

Area	Live Load (psf)
Roof	40 psf
Office	100 psf* including partitions
Stairs and Public Areas	100
Mechanical	75
Wind	Wind tunnel
Seismic	Not applicable

* Reducible

Condition

Where not concealed by building finishes, the building structure appears to be in good overall condition. There is no apparent movement or settlement in foundations. Interior slabs appear in good condition. Basement areas under the Tower were dry.

Structural Integrity Inspections (SII) of various structural systems have been performed on a regular basis by Leslie E Robertson Associates (LERA) and other engineering firms. Deficiencies typically noted are rusting conditions in the steel columns in the elevator shafts, missing fireproofing, and occasional floor coring damage. The most recent SII recommended repairs are underway.

Visco-elastic dampers located at each floor joist at the connection to the perimeter columns dampen the sway motion. Sample dampers are tested every 5 years, most recently in 1996. It is reported that approximately 2 dozen dampers are kept in stock for replacement.

LERA strongly recommends that the analysis of wind acceleration measurements be continued, to monitor the dynamic behavior of the structure. They note that the 30-year-old visco-elastic dampers on the floor open web trusses have a finite life and must continue to be monitored.

2. Exterior

Walls

The building has a square shape, 207' 2" on each side. The facade of the building extends up 1,368' from Lobby Level to the roof. The exterior columns are projecting, and are spaced 10' o/c from Plaza Level to the 6th story, where each column transitions to 3 columns, spaced at 3' 4" o/c. Columns are covered with rectangular-shaped anodized aluminum column covers, with built-in window washing tracks. Spandrel panels between windows are black colored, painted aluminum.

The 110th story facade slopes inward, and extends above the roof level to form the roof parapet.

Windows

Fixed glazed vision glass fits between the column covers (approximately 1' 10" wide and 7' 8" high.). The glass is single pane. Window treatments include venetian blinds.

Window Cleaning Equipment

There is a window-washing rig that rides on rooftop tracks that extend around the roof perimeter. There is also a movable platform that lowers the rig from the roof rails into the interior garage on the 110th floor. A special rig to access the Tower's corners is on site and installation is beginning. It is expected to be in use by next year.

The rig operator can lower the robotic window washing apparatus, or the manned scaffold platform. Stainless steel tracks for the robotic window washing apparatus and manned platform are built into the facade column covers.

Doors

There is a main drive-up entrance at West Street with a large polished stainless steel clad canopy (with multi skylights and mini-spot lighting). This entrance enters into the lobby level vestibule. The entrance has 2 revolving doors, 3 pairs of swing doors, and 1 pair of automatic sliding doors for persons with disabilities.

The entrance to the building at Plaza Level is located facing toward the east. There are 2 revolving doors and 2 pairs of swing doors at this location. There are 2 additional sets of doors on the north and south sides that provide egress to the Plaza, and 1 additional set on the north side that egresses to a bridge to the Plaza.

Revolving doors and swing doors are set between exterior columns, with overhead glazed fixed transoms. All doors have polished stainless steel framing.

Thermal Insulation

Spandrel panels have rigid insulation on the internal face.

Weatherproofing Sealants

There is elastomeric sealant at the juncture of vertical column cover sections. There is rubber gasket glazing for the glass vision panels and glass spandrel panels.

Expansion/Control Joints

Facade expansion joints were not observed, but the column cover system has many components with elastomeric sealants and its expansion and contraction is self-relieving.

Other

The close spaced columnar design of the exterior facade is dictated by structural considerations due to the unique extreme height of the building and the requirement for column-free interior tenant space.

Condition

The building facade appears in good condition with no reported leaks. The facade is regularly inspected and repaired on an on-going 5-year cycle, with 10% of facade monitored by LERA to insure quality control. Structural Integrity Investigation reports are issued annually to the Port Authority. Recent reports note that the window gasketing is starting to exhibit age-related deterioration, and wet sealing is anticipated within 10 years.

The lacquer coated anodized aluminum column covers exhibit finish variations between panels.

Heitmann & Associates Curtain Wall Evaluation is Attachment 9.

3. Roof

Roof Area	The main roof is above the top (110th) story of the building. There is also roofing at the parking area for the window-washing rig on the 110th floor. The exterior walls of the 110th story step back for air intake louvers. The mechanical rooms on the 108th, 75th, 41st, and 7th stories step back 6' to conceal the louvers, and have roofing systems. The roof contains the main antenna for all but 1 UHF New York City television broadcasting stations.
System	The main roof is the original membrane (reportedly asphalt felt built-up system) and is protected by 2" of rigid insulation and a 5" concrete overlay. Setback roofs appear similarly constructed. The setback concrete surfaces were covered with traffic deck membrane in 1995 due to leaks, and reportedly corrected the condition.
Decking	The roof deck is reinforced concrete. The roof slab is sloped up above the central core area of the building.
Drainage	The roofs have internal roof drains.
Parapets/Copings	There is a 3' inward sloping perimeter parapet wall adjacent to the window washing rig tracks. The parapet is the exposed steel facade framing and attached aluminum facade panels.
Flashing	All flashings are flashing membrane extended up and under metal cap flashing set in reglets in concrete curbs.
Expansion Joints	None observed
Penetrations and Equipment Mounting	Penetration flashings are concealed under the concrete topping.
Access	The roof is accessed from the 110th story vestibule, which opens to an exterior stair to the roof.
Skylights	There are no skylights.
Bonds/Warranties	All warranties are expired.

Condition

The main roof, although the original membrane, is protected by a 5" thick concrete overlay, and a large portion is pitched. The roof reportedly does not leak, and should last beyond 10 years. The concrete overlay is displaying age- and exposure-related deterioration, and a top coating is anticipated within the next 5 years.

The concrete fill at the exterior walkways at the mechanical equipment room setbacks has been resurfaced with a waterproof traffic deck, and reportedly does not leak.

4. Interior Construction and Finishes

Lobby Areas

The lobby is the spacious full size of the 207' 2" square floor plate with 6-story high exterior glazed wall and architectural-shaped ceilings visible through the large curved atrium-type openings in the Plaza Level mezzanine 16' above the lobby. The center portion of the lobby contains the rectangular core (87' x 135') which is dedicated to the multiple banks of elevators. Glass paneled railings and security turnstiles with encoded card readers control access to the core elevator system.

The lobby has granite paneled floors with recessed carpeting, 6-story high marble core walls and pilasters with polished stainless steel reflective panels, and marble-faced exterior columns with glass vision lites. Elevator hoist way doors and trim are polished stainless steel. The lobby ceiling is suspended wire lath and plaster, with abutting 15' x 29' rectangular-shaped, concave panels, with ceiling-mounted decorative crystal lens lighting fixtures in each panel. The panels are separated by 7 1/2" plaster trough borders. The ceiling is suspended 9' below the 7th floor, and has catwalks for access. The light bulbs used to be changed from above the hung ceiling, but now are changed by lift.

The east side of the lobby is accessed from the mall concourse, through 14 polished stainless steel-framed, glazed revolving doors with fixed glazed transoms above that fit between the Tower's 10' o/c columns. There are also 2 sets of automatic sliding doors leading to the concourse. The rear of the lobby has a glazed vestibule system at West Street with 2 revolving exterior vestibule doors and 3 pairs of swing doors. This vestibule also has a set of automatic doors for persons with disabilities.

There is a vestibule entrance on the north face of the lobby with 2 sets of escalators and 1 set of stairs that provides access to the Customs building and the bridge across to the World Financial Center. There are 3 elevators ("J" bank) adjacent to the north wall of the lobby that serve the below Grade B-1 to B-6 levels (Tower and all subgrade spaces, including garage access). There is an entrance to the Marriott Hotel on the south wall of the lobby.

There is a marble-faced visitors' counter along the north wall of the lobby, with recessed carpet flooring. A plan is currently in progress for replacement of this carpet and the carpet in the mezzanine of the lobby to meet the test requirements prescribed by the NYC Code. The fire command station is also in the lobby.

The Plaza Level mezzanine above the lobby has a curved atrium type opening on each side of the long dimension (E-W) of the core, extending the full length of the core and 2/3's the 60' wide span on each side of the core. The floors of the Plaza Level mezzanine are granite and the walls are marble.

The Plaza Level mezzanine is accessed from the Plaza on the east face through a pair of revolving doors fitting between the building's 10' o/c aluminum clad columns. There are also 2 pairs of swing doors.

There is a pair of escalators that lead from the lobby to the Plaza Level Mezzanine.

Sky Lobbies

The middle and upper zone elevator systems are served by express elevators running from the main lobby to the sky lobbies at the 44th and 78th stories, where transfers to local service occurs. These lobbies are finished with marble-bordered carpeted floors, verde marble walls, and arched plaster ceilings with chandeliers. Each sky lobby has a pair of escalators leading to the floor above and a pair of escalators leading to the floor below.

Core Corridors

The 87' wide x 135' long central core below the 44th floor sky lobby contains the 4 banks of 6 passenger elevators, all express elevators, freight elevators (49, 50, 17, 5, 6, 7) 3 stair exits, 1 men's and 2 women's toilet rooms, ventilation shafts, electric closets, telephone closets and janitor's closets. Above the 47th floor the core shrinks due to the elimination of the low zone express elevators. Above the 81st floor the core shrinks again, due to the elimination of the high zone express elevators.

Each floor has a "T"-shaped corridor, which accesses 1 bank of 6 passenger elevators, 3 freight elevators (2 freight on upper zone), 3 stair exits, and the toilet and utility rooms. Floors 24, 32, 61, 67, have 2 banks of 6 elevators serving these floors. Multi-tenanted corridor finishes are carpet, rubber base, painted walls, and suspended acoustic tile ceilings. Full floor tenants have individualized good-grade elevator lobby finishes and corridor finishes. Some single-tenanted floors have elevator vestibule access to exits restricted by locked office doors which reportedly operate on a fail safe fire alarm door release system.

Exterior columns have vermiculite plaster surfaces for fire rating purposes.

Tenant Offices

The tenant finishes are typically carpeted floors, vinyl base, painted walls, and suspended lay-in acoustic ceilings with recessed fluorescent fixtures. Some tenants have higher quality finishes.

Rest Rooms

There is typically 1 men's toilet room and 2 women's toilet rooms on each office floor, depending on the elevator shaft layout at a particular story. The toilet rooms have ceramic tile floors, base, and walls, and lay-in suspended acoustic ceilings with downlights. Toilet partitions are ceiling-mounted painted steel. Most toilet rooms observed have the original ceramic tile finishes. Reportedly, 6 floors have been upgraded.

Exits

There are 3 interior exit stairs that serve all office floors. Stairs have painted concrete floors (with photo-luminescent paint directional stripes), painted steel stringer stairs with concrete-filled steel pan treads and intermediate level platforms, painted walls, and painted ceilings. Doors are locked from the stair shaft side, with reentry at every 4th story. One stair exits into the lobby which has egress to West Street and the 2 other stairs exit into the Plaza Level mezzanine which has egress to the exterior Plaza through swing doors on faces of the building.

Sound Insulation

Carpets and suspended acoustic ceilings help to control noise transmission within the building.

Doors

Stair exit doors are self-closing hollow metal fire-rated.

Other

The B-1 level is used mainly for moving freight from the loading docks into the core elevator areas for dispersal throughout the building. It is a raw space with painted floors and walls, and bare ceilings with exposed mechanical services.

The B-2-B-4 areas are primarily used for construction and building maintenance offices, lockers, and storage. There are some tenant storage spaces. Finishes are VCT floors, painted block walls, and suspended ceilings.

Levels B-5 and B-6 house the mechanical equipment for the lower section of the building and for the PATH. Finishes are painted floors, walls, and bare concrete ceilings.

The Windows on the World restaurant occupying the 107th story provides spectacular views of the New York City and its harbor, including overlooking the Statue of Liberty. This luxury facility has 2 restaurants, and 4 banquet rooms. A full kitchen is located on the floor below and an elevator (#99) connects the 2 floors. Toilet rooms are ADA compliant

Freight elevator vestibules have VCT floors, rubber base, painted walls and suspended ceilings.

Condition

Multi-tenant floor common area finishes are typically average quality and are adequately maintained. Corridor carpets are reportedly 2 years old. Elevator vestibules are good durable quality. Most corridors have original concealed spline acoustic ceiling tiles and many are displaying age- and usage-related wear, and replacement should be anticipated. Most toilet rooms are original durable finishes, with localized repairs for cracked tile or damaged tile required, as ordinary maintenance. A capital program was initiated to upgrade multi-tenanted corridors and toilet rooms. Approximately 6 floors have been completed.

Ceramic tile base and wall tile in some toilet rooms was observed to be damaged or cracked, and should be repaired as part of ordinary maintenance.

The 3 stair exit shafts typically display age- and usage-related wear and require floor repainting. Photo-luminescent paint stripes in stairs should be retained. The nosings on Stair B (wide stair) are bent outward in isolated locations in both Towers and require repair.

Lobby and sky lobby finishes are good quality. Structural Integrity Inspection 24 (Data Room List), dated May 1, 1998, recommended additional hangers be installed in the suspended lobby ceiling, which were reportedly installed.

Mechanical equipment floors (108, 41, B-6) require floor repainting, which is planned to be done under the PA's Spit and Polish Program.

5. Vertical Transportation

Overview

There are 72 local stop passenger elevators and 19 shuttle stop passenger elevators serving the above-lobby floors. There are 2 express elevators serving Windows on the World on the 106th and 107th floor. There are 3 elevators ("J" bank) adjacent to the north wall of the lobby that serve the below-grade B-1 to B-6 levels (Tower and all subgrade spaces, especially garage access). The vertical transportation system is divided into 3 vertical zones serviced from the main lobby and the 2 sky lobbies, which are at the 44th and 78th floors. There are 8 shuttle elevators traveling from the lobby to the 44th floor sky lobby and 11 shuttle elevators traveling from the lobby to the 78th floor sky lobby. The main lobby and the sky lobbies each access 4 banks (A, B, C, D) of 6 passenger cars which provide local service to portions of their respective zones. Each local bank of 6 elevators serves approximately 8 stories. The local service stacking design and the 2 sky lobbies, minimize core size and keep floor areas relatively constant in size. Wind sway detectors, located on the 108th floor, automatically activate controllers to decrease elevator speeds during high wind sway conditions.

There are 8 service elevators serving the building, some of which also perform dual function as passenger elevators.

There is one set of escalators serving the Lobby Level to the Plaza Level. There are two pairs of escalators on each sky lobby floor, serving the floor below. Some lobbies also serve the floor above and below the sky lobby.

Cabs

Local service passenger cabs have carpeted floors, porcelain enamel wall panels with a narrow band of exposed marble at rail height, brushed stainless steel front panels, and brushed stainless steel center-opening single-speed elevator doors. The cabs have been updated to ADA compliance.

Express service passenger cabs have carpeted floors, marble wall panels, brushed stainless steel front panels, and brushed stainless steel center-opening double speed elevator doors. The mid-rise car controls have been updated to ADA compliance. Two upper zone car controls (18 and 19) have not been updated.

Maintenance

Maintenance is by full-service contract with Ace Elevator Company. In addition, Port Authority personnel oversee the service contractor's work by conducting regular maintenance inspections.

Inspections

The 5-year test tags are current.

Condition

A representative sampling was observed.

The elevators and escalators appear adequately designed and are maintained under service contract with Ace Elevator Company. The PA performs maintenance Quality Assurance inspections.

Approximately 65% of the original elevator equipment has been modernized with another 3% in progress. Modernization of the balance is either ongoing or planned for prior to the 2nd quarter of 2004. Escalators have been modernized with start/stop switches, comb plate switches, demarcation lights, caution signs, controlled descent devices, and remote monitoring systems.

Two high zone express elevators (18 and 19) require ADA car panels.

The ropes on Car 99 are rusted and require replacement.

For detailed elevator information and description of equipment, refer to Attachment 6, prepared by BOCA Group International.

6. HVAC

Overall Systems

Heating and cooling for the building are provided by central station air handling units (AHUs) and perimeter induction units (PIUs), all utilizing pneumatic controls.

Heat

Medium pressure steam, supplied from the central steam station, goes through pressure reducing stations located in the 108th, 75th, 41st, 7th floors, and B-6 Level mechanical equipment rooms (MERs). The low-pressure steam is piped to coils in AHUs, which supply interior spaces and PIUs on the floors.

Low-pressure steam is also piped to shell and tube heat exchangers in all MERs to produce secondary heating hot water, which is pumped to coils in the PIUs.

Additional heat is supplied by steam unit heaters located in mechanical spaces.

Heat Exchangers	Two shell and tube units for the condenser water system Two plate and frame units for the condenser water system
	Twenty-six shell and tube units for the secondary heating hot water/chilled water system
Air Conditioning	Chilled water from the central plant is supplied to coils in the AHUs and secondary chilled water is supplied to the PIUs. Each PIU has one coil which is used for both heating hot water and chilled water.
	A looped condenser water system is available for tenants' supplementary water-cooled air conditioning units.
Pumps	Four 1,400-gpm, 150-hp condenser water pumps One 40-hp condenser water pump
	For Floors 9 - 24: Four 40-hp, 890 gpm secondary water pumps, 2 standby
	For Floors 25 - 58: Two 40-hp, 580 gpm secondary water pumps, 1 standby Four 40-hp, 745 gpm secondary water pumps, 2 standby Two 40-hp, 990 gpm secondary water pumps, 1 standby
	For Floors 59 - 74: Two 40-hp, 580 gpm secondary water pumps, 1 standby Four 40-hp, 745 gpm secondary water pumps, 2 standby Two 40-hp, 990 gpm secondary water pumps, 1 standby
	For Floors 92 - 105 Two 40-hp, 580 gpm secondary water pumps, 1 standby Two 40-hp, 745 gpm secondary water pumps, 1 standby
	For Floors 106 - 107 Two 7.5-hp, 245 gpm secondary water pumps, 1 standby
	Two duplex steam condensate pumps
Air Handling Units	There are 8 AHUs located in the B-6 Level MER, rated at 13,000 to 38,000 cfm with 15 hp to 40 hp motors, that supply the loading dock, PATH areas, and other subgrade levels.
	Fourteen central AHUs, located in the 7th floor MER, rated from 14,200 to 79,000 cfm with 15 hp to 100 hp motors, supply conditioned air to interior spaces and the PIUs.

Sixteen central AHUs, located in the 41st floor MER, rated from 6,000 to 95,000 cfm with 10 hp to 125 hp motors, supply conditioned air to interior spaces and the PIUs.

Eighteen central AHUs, located in the 75th floor MER, rated from 10,000 to 98,000 cfm with 10 hp to 150 hp motors, supply conditioned air to interior spaces and the PIUs.

Sixteen central AHUs, located in the 108th floor MER, rated from 10,000 to 91,000 cfm with 10 hp to 150 hp motors, supply conditioned air to interior spaces and the PIUs.

One AHU with a steam coil, located on the 110th floor, is used for the antenna heating system.

Fans

Toilet, AHU return air, kitchen, and mechanical room exhaust fans are installed.

Condition

The mechanical systems are adequately designed, using brand-name equipment, which provides adequate cooling for the office areas. To allow for the expanded substations in the 41st and 75th floor MERs, 4 AHUs were removed and new AHUs were installed. The original freeze protection system for the AHUs and reheat system for the heating hot water system have been abandoned in place, and consideration should be given to removal of the equipment for these systems. On the 108th MER, as a result of year round cooling demands, a new freeze protection system has been installed. This system includes 2 circulating pumps and a heat exchanger that will circulate chilled water to all of the AHUs in this MER, instead of each AHU having its own pump. The same work will be performed in the remaining MERs over the next 5 years. The equipment has been well maintained, nearly all of the equipment is original (30 years old), and has or will exceed its published service life over the next 10 years, and replacement should be anticipated. A recent capital program to update the HVAC air-handling equipment has effectively increased the anticipated service life of the equipment. Equipment or component maintenance and repair is performed as part of the ABM service contract.

7. Plumbing

Storm and Sanitary Sewers

Roof storm water is collected by roof drains and conveyed by internal leaders to the building's storm sewer.

Sanitary waste flows by gravity to the building's sewer.

Water Service

Metered city water, with a backflow preventer, enters a pump room on the B-1 Level and goes to Pump Station (PS) 1 which serves the B-1 Level up to the 41st floor. On the 7th floor MER, the water goes through a pressure reducing station and is supplied up to the 24th floor. Floors 25 - 41 are fed directly by PS1. On the 41st floor MER the water goes to PS2 which supplies Floors 41 - 75, and a pressure reducing station before going to Floors 41- 58. Floors 59 - 75 are fed directly by PS2. PS3, located in the 75th floor MER, supplies Floors 75 - 108. In the 108th floor MER the water goes through a pressure reducing station and is supplied to Floors 75 - 92. Floors 93 - 108 are fed directly by PS3.

Water Pipe Material

Copper supply piping was observed.

Domestic Water Heaters

Domestic hot water is provided by steam/water pre-heat tanks, steam/hot water heaters, and electric water heaters located in the 7th, 41st, 75th, and 108th MERs.

Pumps

One 60-hp, 292 gpm domestic water pump on the B-1 level supplying the 41st floor MER

Three 100-hp, 530 gpm domestic water pumps on the B-1 Level supplying the 41st floor MER

One 40-hp, 239 gpm domestic water pump in the 41st floor MER supplying the 75th floor MER

Three 75-hp, 477 gpm domestic water pumps in the 41st floor MER supplying the 75th floor MER.

One 40-hp, 239 gpm domestic water pump in the 75th floor MER supplying the 108th floor MER

Three 75-hp, 424 gpm domestic water pumps in the 75th floor MER supplying the 108th floor MER.

Four 7.5 hp circulating pumps are installed for the water heaters.
Eight 1.5 hp circulating pumps are installed for the water heaters.

Toilet Rooms

There are 2 sets of women's and 1 men's toilet rooms on each typical office floor.

Condition

There have recently been problems with the failure of water hammer arrestors and leaks (see the Executive Summary). Although in operation, replacement of pumps and water heaters should be anticipated over the next 10 years. Equipment or component maintenance and repair is performed as part of the ABM service contract.

8. Electrical

Main Service

The Primary Distribution Center (PDC) on the B-3 Level supplies 13.8 kV primary electrical service to 10 electrical sub-stations in 1 WTC. There is 1 substation on the B-1 Level, 2 substations, on the 7th, 41st, and 75th floor MERs, and 3 substations on the 108th floor MER. Each substation is served by four 13.8-kV high voltage feeders which is steeped down to 480/277 volts. The substations on the B-1 Level and 7th floor MER and the 2 on the 108th floor MER each have 2 switchboards with 4,000-ampere main breakers. The substations on the 41st and 75th floor MERs and the remaining substation on the 108th floor MER each have 4 switchboards that are in a tie bus configuration. Normal power is distributed to the tenants through 120/208-volt and 277/480-volt bus ducts located in 2 electric closets on each floor.

Capacity

An adequate 10 watts/sq. ft. is provided from the 25th floor through the 105th floor. Six watts/sq. ft. is available in the remaining areas of this Tower.

Wiring

Copper and aluminum wiring, with mechanical connectors, was observed between disconnect switches on bus duct risers and power panels.

Emergency Power

Six generators, located in the central plant, supply emergency power for lighting, elevators, and the life safety system. Power is distributed throughout the Tower through one electric closet on each floor. Certain select feeders are backed up by the tertiary power substation originating from PSE&G via the PATH system. Tenant stand-by power is provided from a central plant located on the roof of 5 WTC. The power is distributed through two 13.8-kV feeders to 3 substations located in MERs on the 41st, 108th and 109th floors.

101

Lighting	Recessed, surface- and wall-mounted, and suspended fluorescent fixtures, and wall-mounted incandescent fixtures provide interior building lighting.
Other	Four telephone/communication closets are located on each typical office floor.
	A closed circuit television (CCTV) system is installed.
Condition	The electrical systems are functioning satisfactorily. The electrical system is infrared scanned on a regular basis.

9. **Life Safety**

Sprinklers	The office floors of the building have been retrofitted with sprinklers, except for electric and telephone closets, most toilet rooms, the main lobby, and the B-6 Level MER. A sprinkler riser control room is located on each floor, with branch lines for the floors sprinklers and flow and tamper switches.
Fire Standpipe	A standpipe riser, with a fire hose rack on each floor, is installed in each stairway.
Fire Pumps	A 100-hp, 1,500 gpm electric pump located on Level 294 supplies sprinklers on Levels B-1 and 310
	A 30-hp, 500 gpm, electric pump in the 108th floor MER supplies sprinklers on Floors 99 and 110
	Standpipe/fire hose racks are supplied by:
	300-hp, 750-gpm electric fire pumps on Level 294 and in the 7th, 41st, and 75th floor MERs
Tanks	5,000 gal. rectangular steel fire reserve tank, located on the 110th floor, for the standpipe risers
	5,000-gal. rectangular steel fire reserve tank, located in the 75th and 41st floor MERs, and on the 20th floor
	10,000-gal. rectangular steel fire reserve tank, located on the 110th floor, for the sprinklers on Floors 33 - 108
Fire Alarm System	A Sieman's Cerebrus Pyrotronics MXL fire alarm system is installed with control and annunciator panels, manual pull stations, alarms, audio/visual alarms, strobe lights, flow and tamper switches, fire warden telephones, and smoke detectors.

Fire Extinguishers	Fire extinguisher cabinets are located in each stair on each floor and in the MERs.
Emergency Lighting	Fluorescent fixtures, with battery back-up, are located in the stairs, and all elevators in the complex have 2-hour battery back-up lighting. Selected fixtures are connected to emergency circuits.
Exit Lighting	Illuminated exit signs are provided which are connected to emergency circuits.
GFIs	Installed in some toilet rooms.
Condition	The life safety systems are typical for a Class "A" office building and meet the New York City Code. A new fire alarm system is currently being installed. Some of the toilet rooms have electrical outlets without ground fault interruption (GFI) protection, which is recommended.

10. Energy Conservation

General	The building was constructed with certain energy conserving features such as insulated walls and roofing, and SCR drives on the elevators. The elevator relay controllers are being replaced with microprocessors. Most of the lighting fixtures use energy saving fluorescent lamps and electronic ballasts.
Energy Management	The building does not have an energy management system.

11. ADA Compliance

Overview	For the purpose of this report, a general review of the property has been conducted to determine basic compliance with Title III of the federally-enacted ADA, dated July 26, 1990. Under the ADA, buildings initially occupied after January 26, 1993 (or building areas altered after January 26, 1992), are required to comply with ADA Accessibility Guidelines (ADAAG). Projects, with areas of public accommodation, constructed prior to this date are required to comply forthwith, to the extent it is "readily achievable." Provisions in the Act require Owners of existing properties with public accommodations to identify barriers for physically disabled persons, that exist on the site or in buildings. The barriers should be systematically removed according to a given set of priorities, the degree allowed by structural feasibility, and the financial resources available. The obligation to remove barriers is a continuing one.

The ADA sets forth "recommended priorities for public accommodations" to be accessible to the disabled. In general, the three priorities are as follows:

1. Access from public sidewalks, parking, or public transportation to a building entrance;
2. Access to any areas of goods and services that are made available to the public; and,
3. Access to rest room facilities.

During our tour of the project, we noted the following:

The building's primary entrance is from West Street into the Tower lobby through automatic power operated entrance doors. The path to the elevators is accessible. The Concourse entrance also has 2 sets of automatic doors.

The Plaza Level main entrance has 2 sets of swing doors, without automatic door opening hardware. Provide door-opening hardware on 1 set of swing doors to make the entrance accessible.

The banks of local elevators and mid-zone express elevators are equipped with car control panels that comply substantially with ADAAG. Two upper zone elevators (19 and 19) are not equipped with complying car controls.

Some (approximately 25%) toilet rooms have had upgrades for ADA requirements, but in most rooms observed, there were noncompliant items such as lack of full size ADA toilet stalls, and ADA compliant urinals. ADA compliance on most full tenant floors is reportedly the responsibility of the tenant under terms of the lease.

12. Code Compliance

Applicable Code	1968 NYC Building Code as Administered by the Port Authority of New York and New Jersey
Building Construction Classification	Class1-B - noncombustible, fire-protected, retrofitted with sprinklers in accordance with Local Law 5/1973
Occupancy Type	Group E - Business

Violations Record

As stated in the Offering Memorandum, "The Port Authority is a municipal corporate instrumentality and political subdivision of the States of New York and New Jersey which provides transportation, terminal, and other facilities of commerce within the Port District. As such, in connection with the Transaction, the PA will continue to maintain exclusive jurisdiction with respect to certain administrative and governmental matters involving the Complex, including compliance with building, environmental, fire and health codes." The New York City Department of Buildings has indicated that they do not maintain any records of violations for this property. A request for a Property Profile Overview for this block and lot number yields no records. The Fire Department provides normal fire fighting and a life safety service to the facility. A Memorandum of Understanding exists between the Port Authority and the Fire Department in which the Fire Department performs regular inspections and directly notifies the Port Authority Fire and Life Safety group of deficiencies to be corrected. Under a protocol with the New York City Fire Department, Port Authority Police personnel investigate certain fire alarms at the World Trade Center rather than transmitting such alarms to the New York City Fire Department.

Certificate of Occupancy

A Certificate of Occupancy has not been issued by the City of New York because property owned by the Port Authority is not subject to the Building Code of the City of New York. We have observed "Permits to Use or Occupy" issued by the Port Authority for specific work, notably the October 10, 1997, Permit issued following completion of repairs following the 1993 bombing, but the Port Authority did not routinely issue the equivalent of a Base Building Occupancy Certificate until January 1992. In addition, in December 1995, the Port Authority started an optional "Professional Self-Certification" program for alteration work by tenants. The PA has issued "Consent to Occupy" certificates for specific work under this program.

E. Recommendations

We have prepared a listing of items that will require action within the next 10-year period. Immediate expenditures indicate deficiencies which are in violation of codes, which pose a danger to public safety, or which, if left uncorrected, will lead to further deterioration of the property or significantly impact marketability or habitability. Recommended work, not required by agencies or codes, which, in our opinion, represents expenditures that should be made in the context of the prudent management of the property is also listed. These items should be undertaken on a priority basis. Items have been divided into 1- to 5-year and 6- to 10-year time frames.

	IMMEDIATE (0 - 1 YR.)	FUTURE (1 - 5 YRS.)	FUTURE (6- 10 YRS.)
General			
1. The net lessee must continue installation of the new fire alarm system and phased implementation of Local Law 5 and 16 requirements. It is reported that the FDNY has approved this approach.	X	X	X
Structure			
2. Structural Integrity Inspection (SII) reports have been performed on an ongoing basis by Leslie E Robertson Associates (LERA) and other engineering firms, on many of the structural components of all WTC buildings. Deficiencies typically noted are rusting conditions in the steel columns in the elevator shafts, missing fireproofing, and occasional floor coring damage. Reportedly, the deficiencies noted in the most recent reports (i.e., SII 73 Data Room List) are being corrected.	X	-	-

		IMMEDIATE (0 - 1 YR.)	FUTURE (1 - 5 YRS.)	FUTURE (6- 10 YRS.)
3.	Visco-elastic dampers located at each floor joist at the connection to the perimeter columns dampen the building's sway motion. Sample dampers are tested every 5 years, the most recent in 1996 (SII 51, Data Room List). Retesting is due this year. Availability of replacement dampers must be ascertained. Responsibility for ultimately replacing these units should be clarified. Reportedly 2 dozen spares are available.	X	-	-
4.	LERA strongly recommends (SII 72, Data Room List) that the analysis of wind acceleration measurements be continued, to monitor the dynamic behavior of the structure. They note that the 30-year-old visco-elastic dampers on the floor open web trusses have a finite life and must be monitored.	X	-	-
Exterior				
5.	Recent SII reports note that the window gasketing is starting to exhibit age-related deterioration. The need for a phased program of wet sealing the gaskets should be anticipated.	-	-	X
6.	The clear lacquered-coated anodized aluminum column covers exhibit finish tinting variations between panels. This does not affect the physical performance of the column covers. Cleaning of the facade is recommended.	-	-	X

	IMMEDIATE (0 - 1 YR.)	FUTURE (1 - 5 YRS.)	FUTURE (6- 10 YRS.)
Roof			
7. The concrete topping is displaying age- and exposure-related deterioration, and a top coating is anticipated within the next 5 years.	-	X	-
Interiors			
8. The floors of the 3 stair exit shafts typically display age- and usage-related wear and require repainting.	X	X	-
9. Mechanical equipment floors (110, B-6) require floor repainting, which is planned to be done under the PA's Spit and Polish Program.	X	-	-
10. Ceramic tile base and wall tile in some toilet rooms was observed to be damaged or cracked, and should be repaired as part of ordinary maintenance.	-	-	-
11. The steel pan stair tread nosings on Stair B (wide stair) are bent outward in isolated locations and require repair.	X	-	-
12. Replacement of 12" x 12" concealed spline corridor ceilings on multi-tenant floors is anticipated. A capital program was initiated to upgrade multi-tenanted corridors and toilet rooms. Approximately 6 floors have been completed.	-	X	-

	IMMEDIATE (0 - 1 YR.)	FUTURE (1 - 5 YRS.)	FUTURE (6- 10 YRS.)
13. Lobby and sky lobby finishes are good quality. SII 24 (Data Room list), dated May 1, 1998, recommended additional hangers be installed in the suspended lobby ceiling, which were reportedly installed.	-	-	-
Vertical Transportation			
14. Approximately 65% of the original elevator equipment has been modernized. Modernization of the balance is anticipated.	-	X	-
15. The ropes on Car 99 are rusted and require replacement. Work should be performed under the existing service contract.	X	-	-
HVAC			
16. Considering the age (30 years) of most of the mechanical equipment, ongoing phased replacement of components should be expected to continue over the next 10 years. This required maintenance is currently accomplished under the terms of the service contract with ABM.	X	X	X
17. Consideration should be given to removal of the pumps and bases, piping, heat exchangers, and valves related to the chilled water freeze protection and hot water reheat systems no longer in use.	-	X	-
18. HVAC distribution system rehabilitation and capacity upgrades are budgeted over the next 5 years.	-	X	-

	IMMEDIATE (0 - 1 YR.)	FUTURE (1 - 5 YRS.)	FUTURE (6- 10 YRS.)
19. Installation of a new freeze protection system is budgeted over the next 5 years .	-	X	-
20. Upgrades to the HVAC controls and smoke management systems is budgeted over the next 5 years.	-	X	-
Plumbing			
21. Replacement or refurbishment of the various pumps and water heaters should be anticipated over the next 10 years as the equipment reaches the limits of service life. This required maintenance is currently accomplished under the terms of the service contract with ABM.	X	X	X
22. Phased replacement of water hammer arrestors is necessary.	X	X	X
Electrical			
23. An electrical capacity upgrade in Zone 3 is budgeted over the next year.	-	X	-
Life Safety			
24. Replace unprotected electrical outlets with GFI protected outlets in all toilet rooms.	X	-	-
25. Fire alarm system upgrades and office space security systems are budgeted over the next 2 years in PA and tenant areas.	-	X	X

ADA

During our tour of the project, we noted the following areas that do not appear to meet the requirements of ADAAG and suggest that these features be added when feasible or when areas are renovated.

1. Some (25% approximately) toilet rooms on multi-tenanted floors have had upgrades for ADA requirements, but in most rooms observed, there were noncompliant items such as lack of full size ADA toilet stalls and ADA compliant urinals. ADA compliance on most full tenant floors is reportedly the responsibility of the tenant under terms of the lease.

2. 2 Upper Zone elevators (18 and 19) are not equipped with complying car controls.

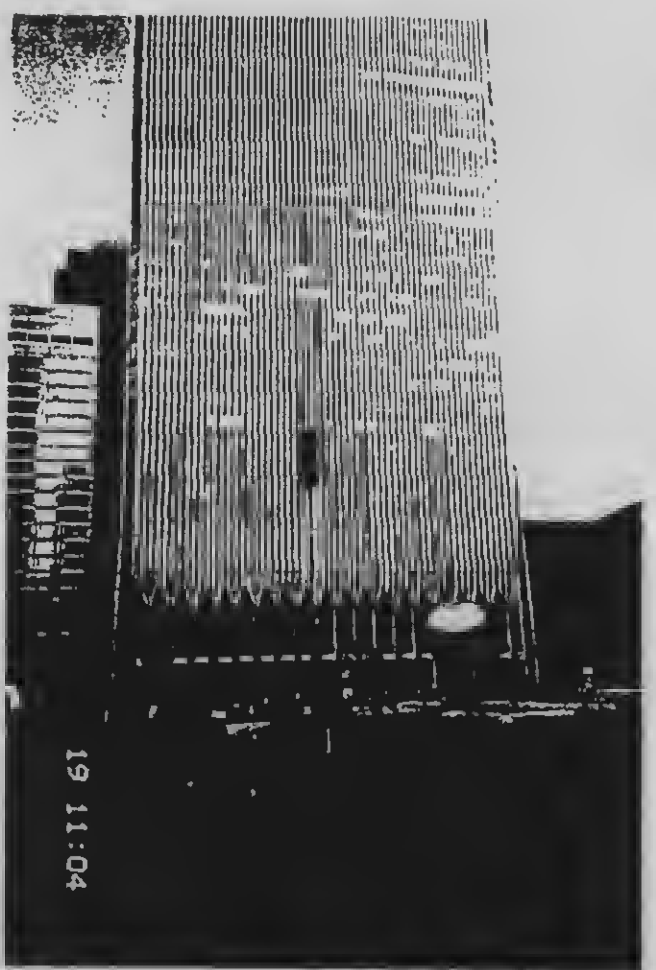
3. Provide automatic door opening hardware on 1 set of swing doors at the Plaza Level entrance.

F. Attachments

1. Photographs
2. Site Orientation Map (Reproduced with permission from J.P. Morgan Property Book)
3. Lobby Floor Plan (Reproduced with permission from J.P. Morgan Property Book)
4. Typical Floor Plan (Reproduced with permission from J.P. Morgan Property Book)
5. Stacking Plan (Reproduced with permission from J.P. Morgan Property Book)
6. BOCA Group International Vertical Transportation Study
7. Crandlemere and Associates Asbestos-Containing Materials Document Review and Evaluation
8. Crandlemere and Associates Roof-Mounted Transmission Devices Document Review and Evaluation
9. Heitmann & Associates Curtain Wall Evaluation

ATTACHMENT 1

Photographs

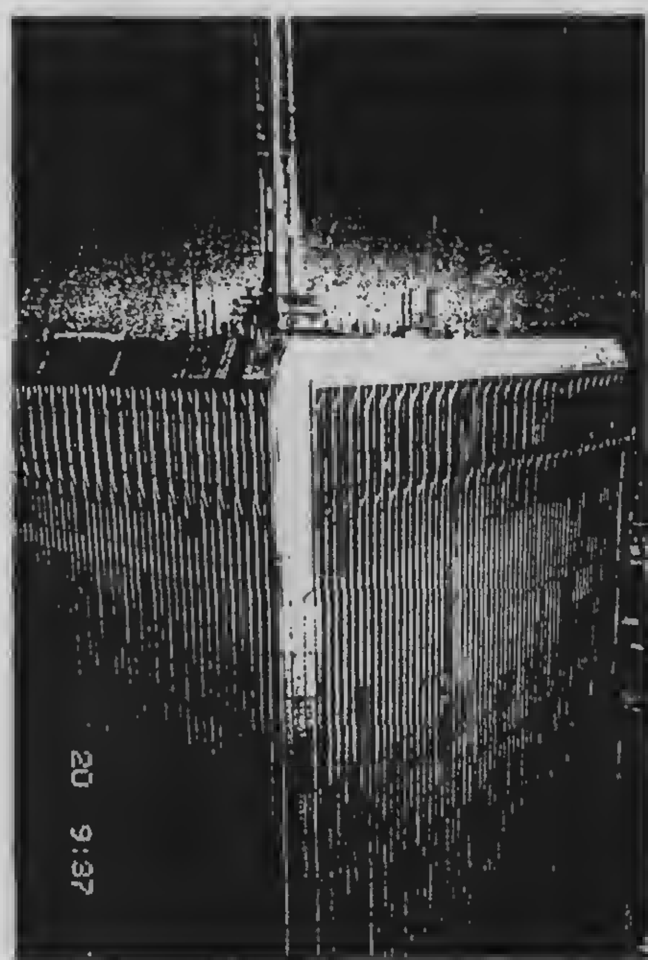


Photograph 1

Front plaza level entrance (east)

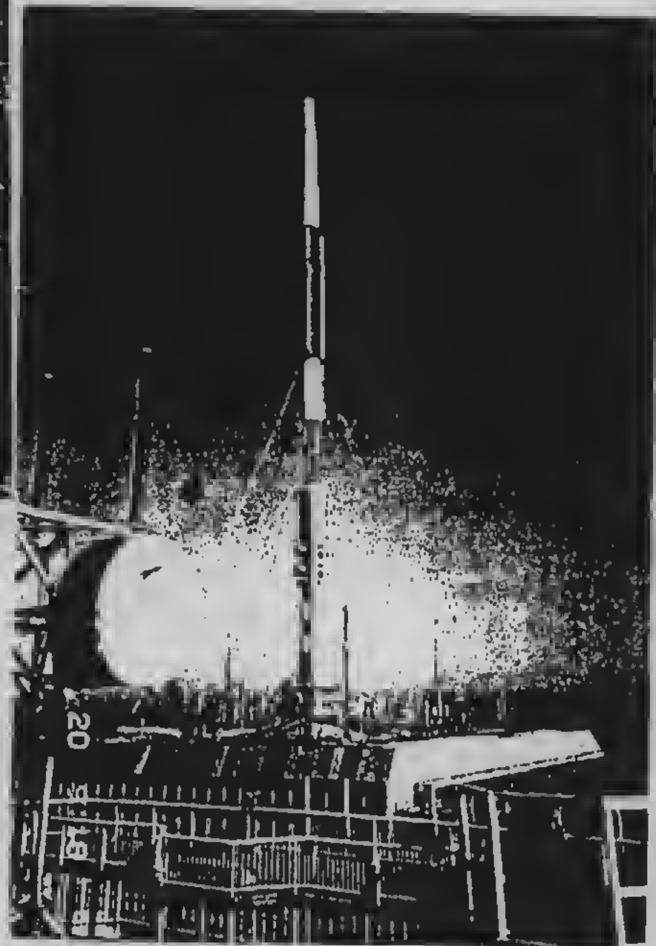
Photograph 2

West Street Entrance to Lobby



Photograph 3

Rooftop and antenna



Photograph 4

Antenna

<u>Photograph 5</u>

Window washing rig

<u>Photograph 6</u>

Typical setback at MER levels

Photograph 7

Lobby with plaza level mezzanine above

Photograph 8

Lobby and elevator banks

Photograph 9

Lobby entrance from mall, and escalators to mezzanine

Photograph 10

Lobby entrance and vestibule on West Street

Photograph 11

Lobby suspended plaster ceiling panels

Photograph 12

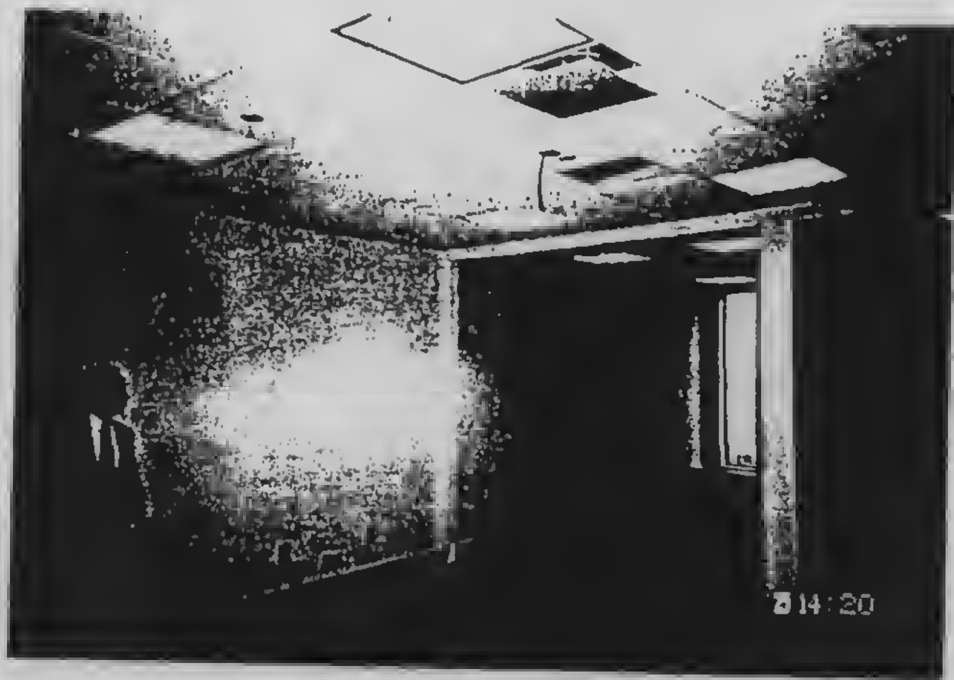
Typical multi-tenanted floor corridor

Photograph 13

Typical multi-tenanted floor elevator vestibule

Photograph 14

Typical office



Photograph 15

Vacant space

Photograph 16

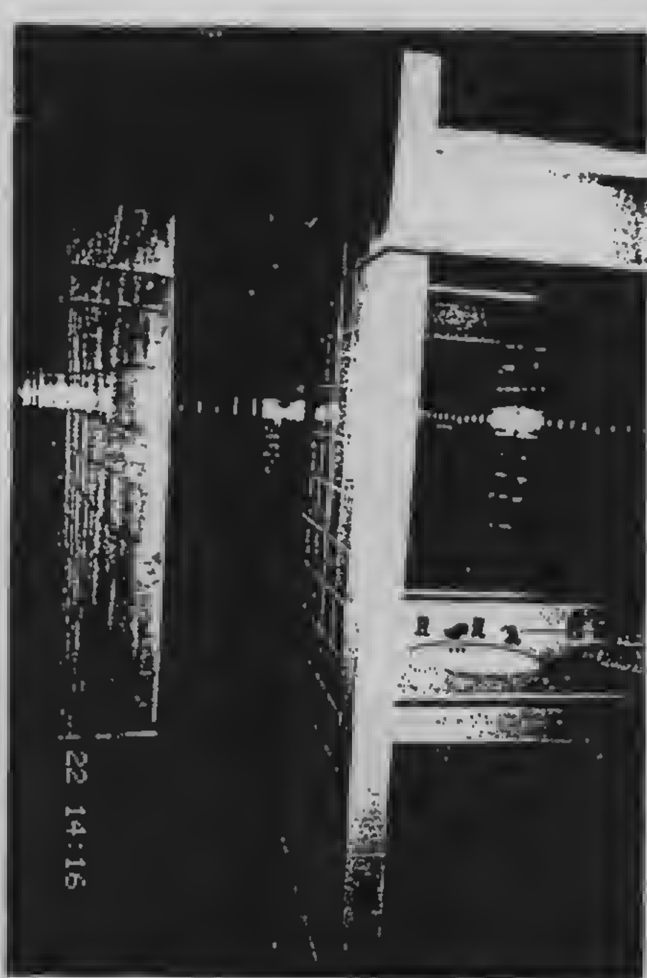
Windows on the World rest room

Photograph 17

Port Authority Cafeteria on 43rd floor

Photograph 18

Port Authority Cafeteria on 43rd floor



Photograph 19

Upgraded toilet room

Photograph 20

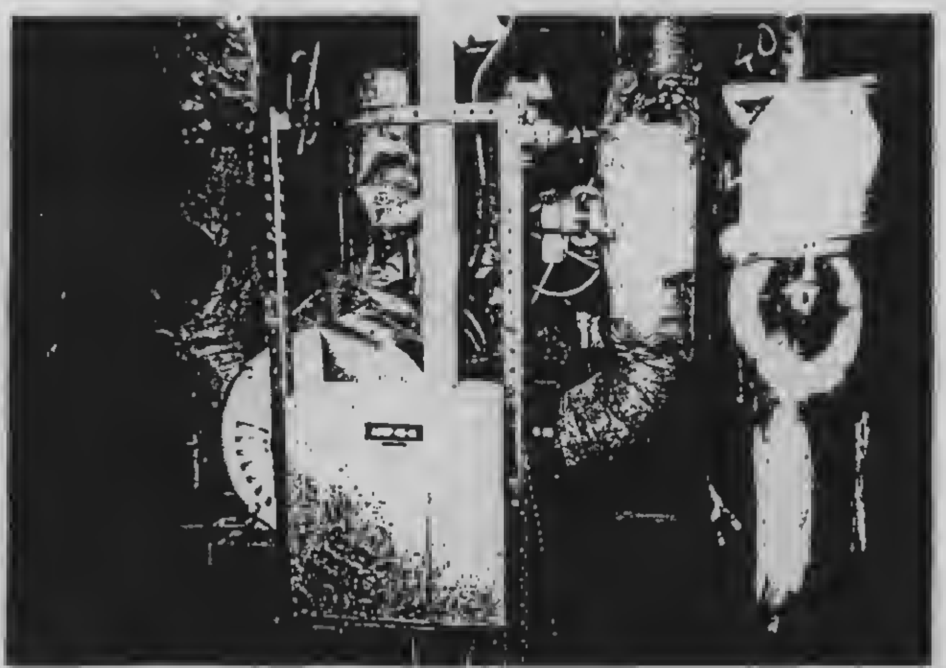
Elevator vestibule
Level B3 for garage

Photograph 21

Bent stair nosing on wide stairs.

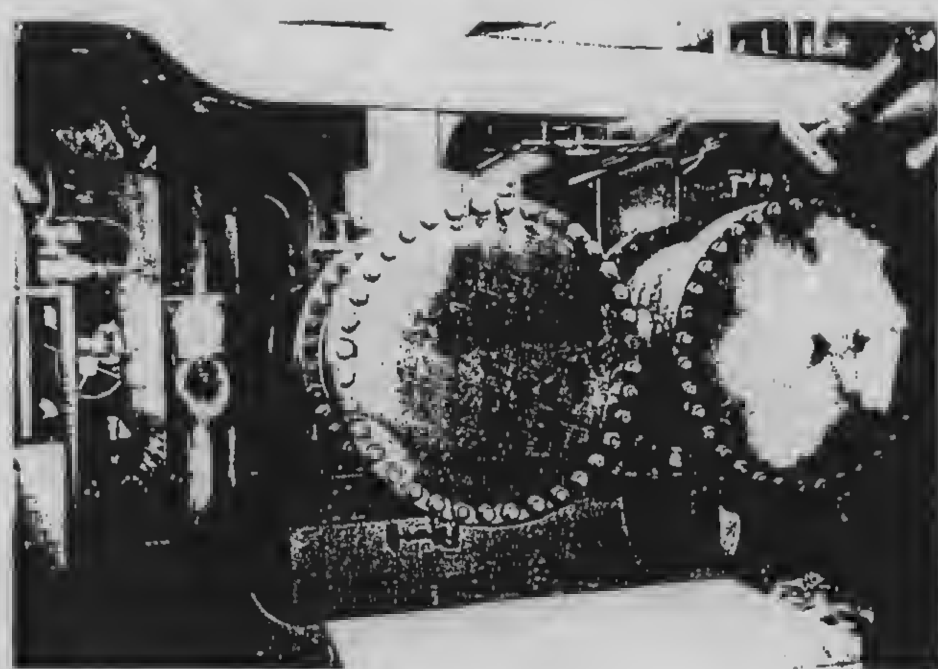
Photograph 22

Viscoelastic damper at each floor joist.



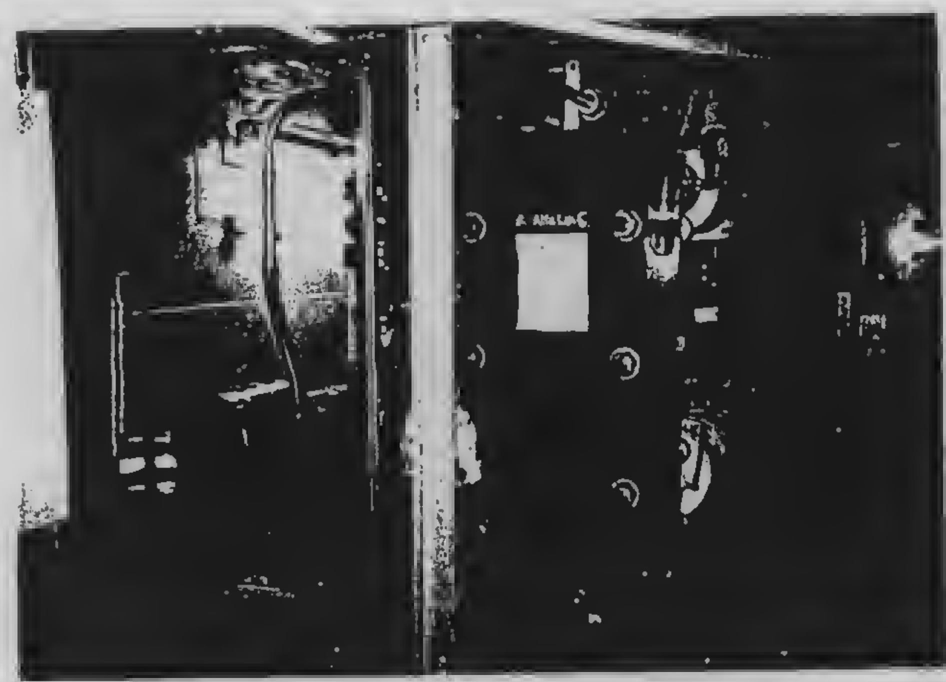
Photograph M1

Condenser water system #2 pump



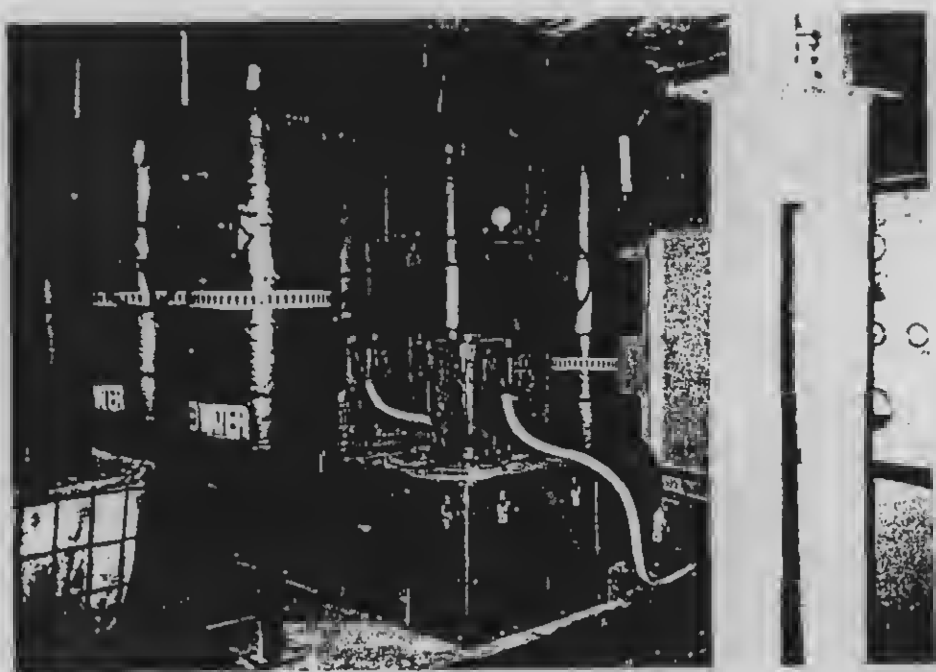
Photograph 2

Condenser water system #2 heat exchangers



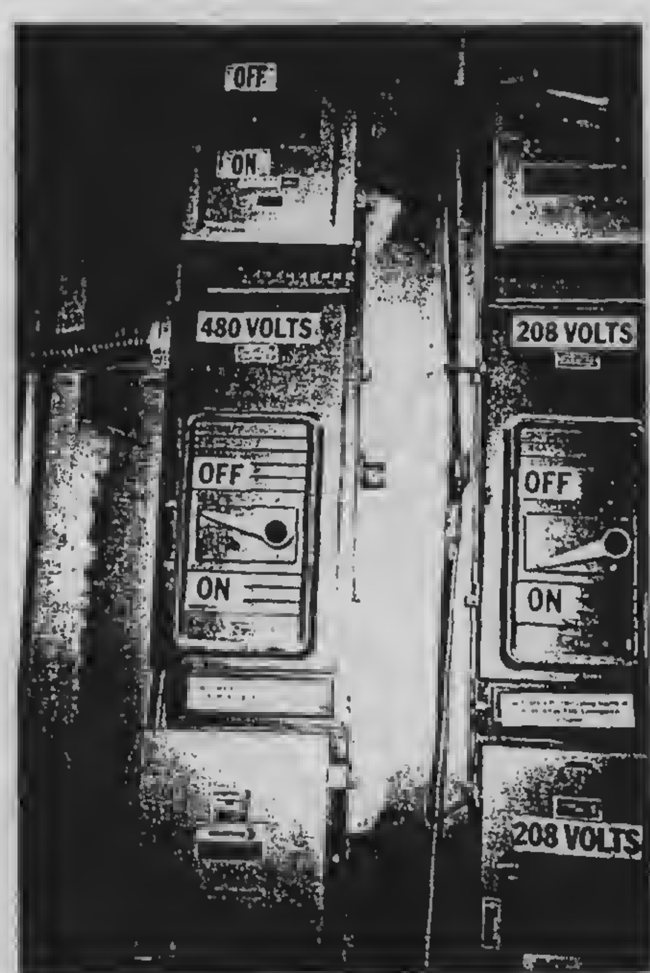
Photograph M3

New condenser water system #2 pump and plate and frame heat exchanger



Photograph M4

New freeze protection system chilled water pumps

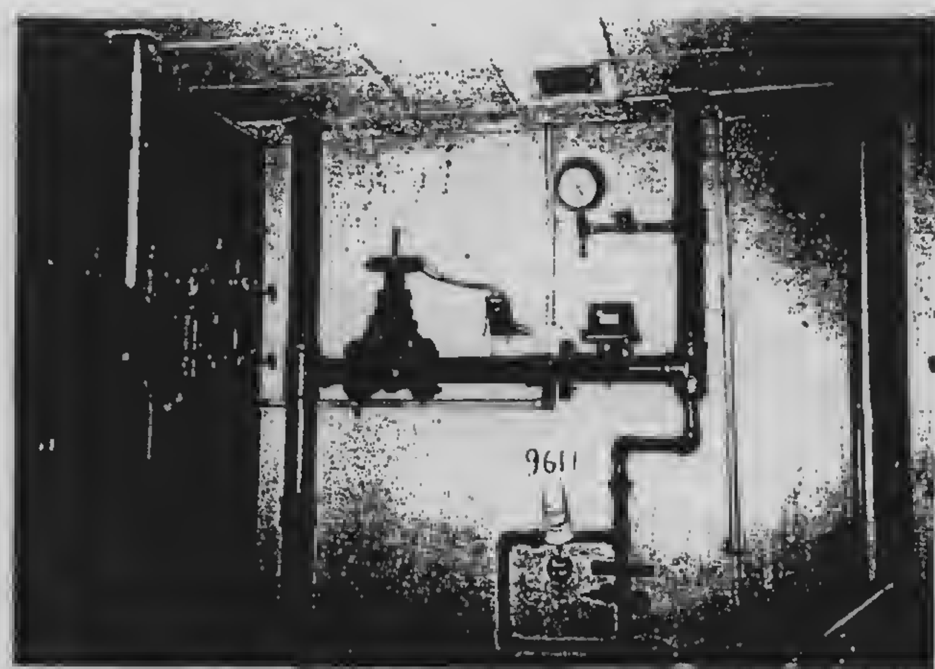


Photograph M5

480 volt and 208 volt electric bus duct risers located in a typical electric closet

Photograph M6

5,000 gal. standpipe fire reserve tank



Photograph M7

Typical floor sprinkler control valve room with sprinkler supply line and flow and tamper switches

Photograph M8

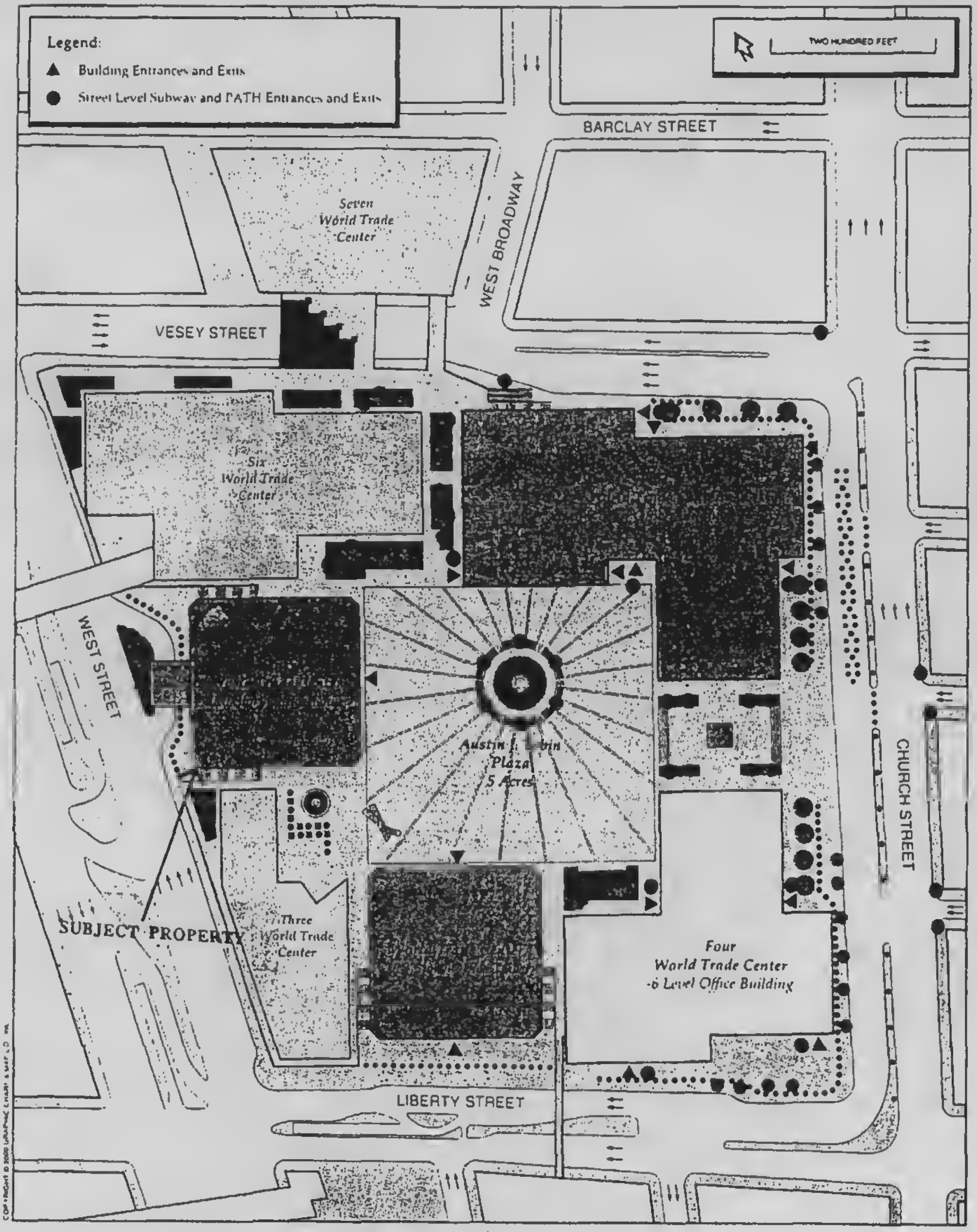
Standpipe riser with a fire hose rack, and fire extinguisher cabinet located in the stairs

PhotographM9

Typical office floor corridor with an exit sign, manual pull station, fire warden station, and audio/visual alarm

ATTACHMENT 2

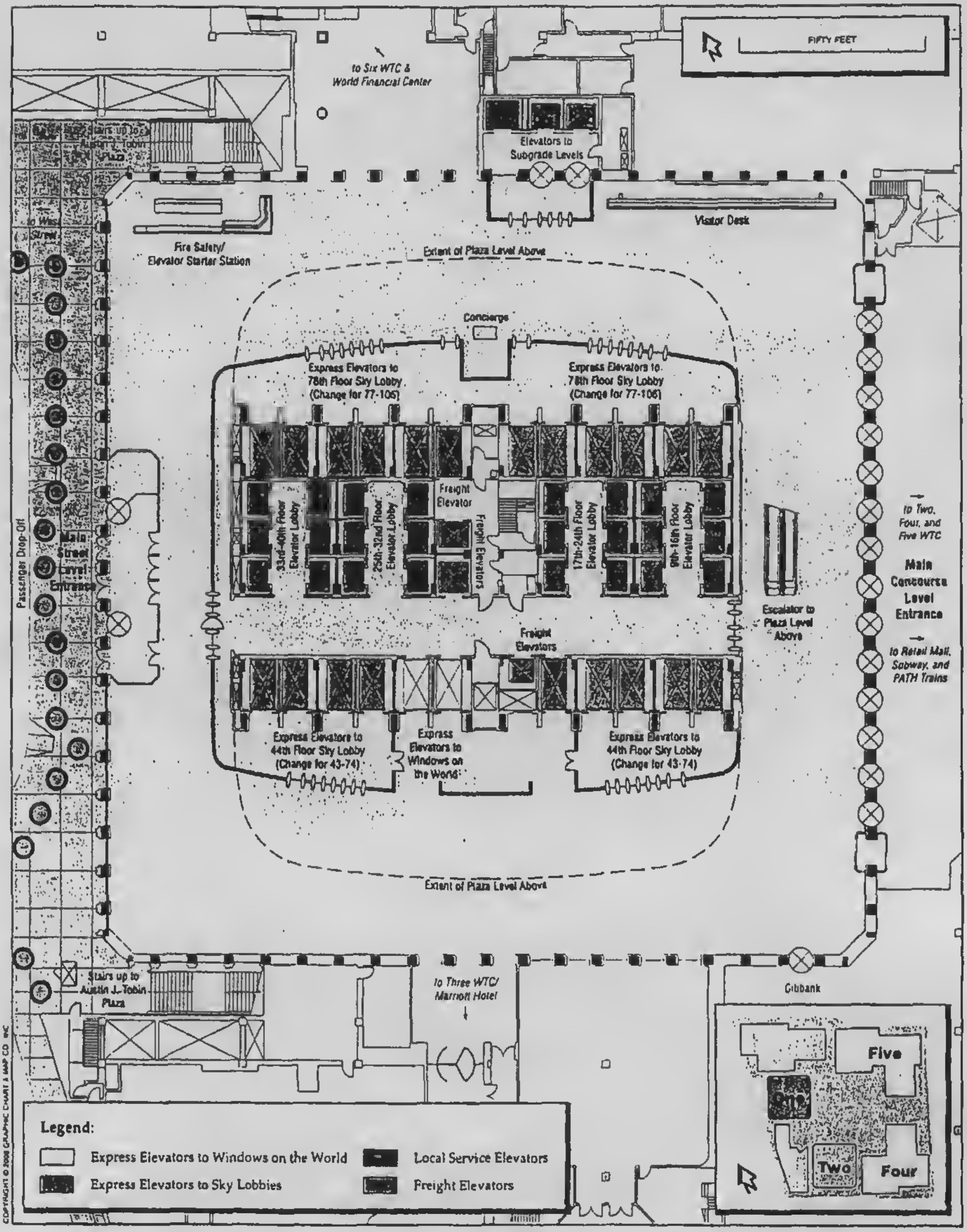
Site Orientation Map
(Reproduced with permission from J.P. Morgan Property Book)


Legend:
Building Entrances and Exits
Street Level Subway and PATH Entrances and Exits
TWO HUNDRED FEET
BARCLAY STREET
Seven World Trade Center
WEST BROADWAY
VESEY STREET
Six World Trade Center
WEST STREET
Plaza
5 Acres
CHURCH STREET
SUBJECT PROPERTY
Three World Trade Center
Four World Trade Center
6 Level Office Building
LIBERTY STREET

ATTACHMENT 3

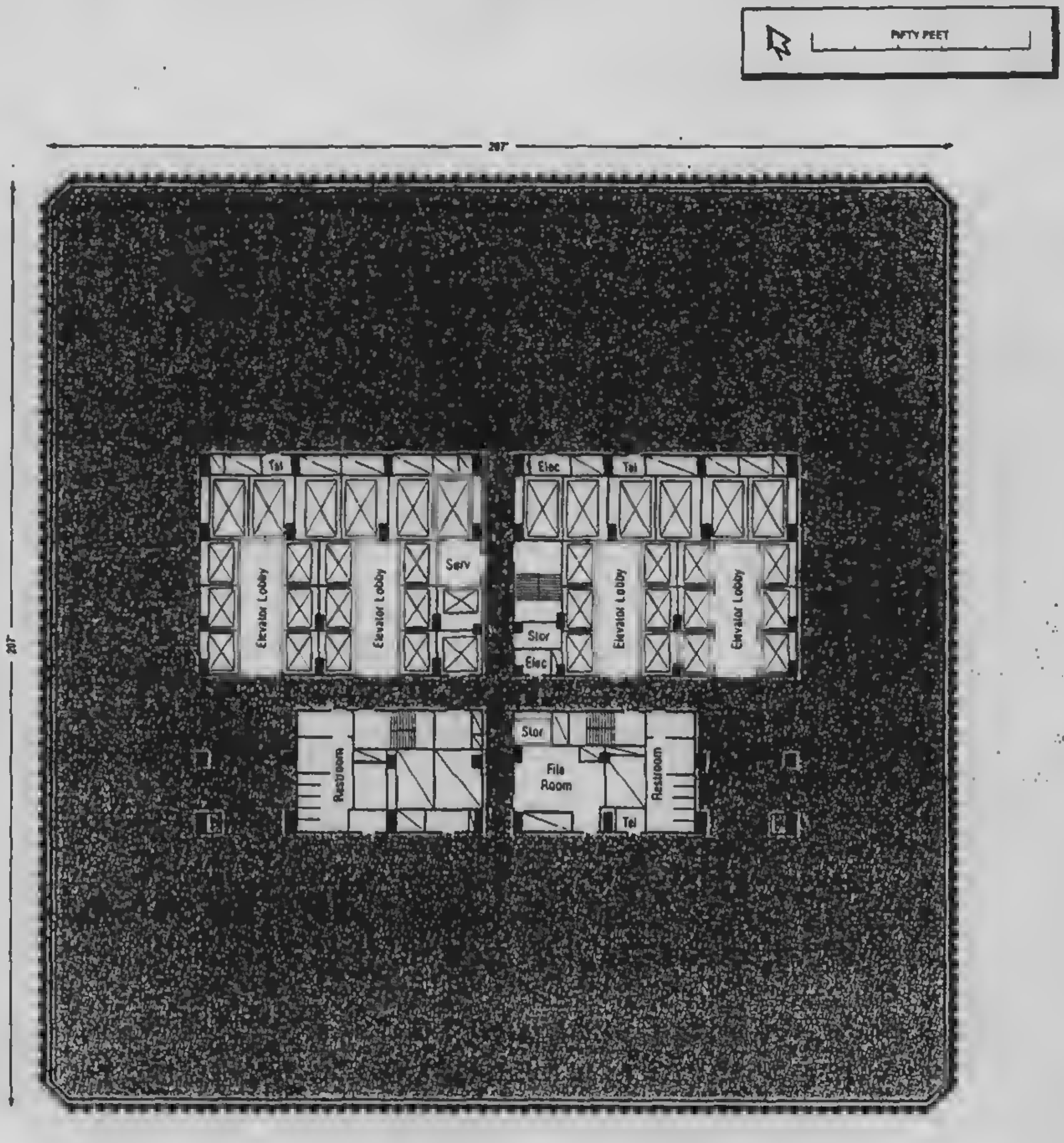
Lobby floor plan
(Reproduced with permission from J.P. Morgan Property Book)

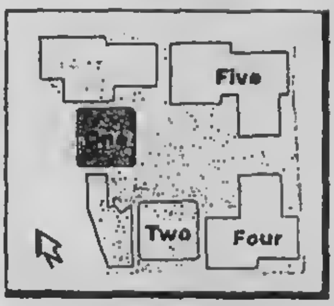
One World Trade Center Lobby Floor Plan



ATTACHMENT 4

Typical floor plan
(Reproduced with permission from J.P. Morgan Property Book)





One World Trade Center

Typical Floor Plan:

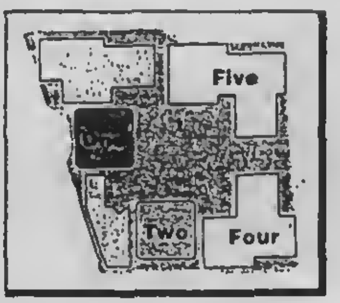
Floor Size: Up to 50,000 Square Feet

ATTACHMENT 5

Stacking Plan
(Reproduced with permission from J.P. Morgan Property Book)

Zone	Floor	Tenant	Rentable Area (SF)
	110	[redacted]	45,064
	108	Mechanical and Equipment Room	
Zone 3	107	[redacted]	49,930
Zone 3	106	[redacted]	50,031
Zone 3	105	[redacted]	50,074
Zone 3	104	[redacted]	50,239
Zone 3	103	[redacted]	50,395
Zone 3	102	[redacted]	49,389
Zone 3	101	[redacted]	49,453
Zone 3	100	[redacted]	49,914
Zone 3	99	[redacted]	50,029
Zone 3	98	[redacted]	50,029
Zone 3	97	[redacted]	50,029
Zone 3	96	[redacted]	50,029
Zone 3	95	[redacted]	48,994
Zone 3	94	[redacted]	48,999
Zone 3	93	[redacted]	49,098
Zone 3	92	[redacted]	49,421
Zone 3	91	[redacted]	49,421
Zone 3	90	[redacted]	49,421
Zone 3	89	[redacted]	49,421
Zone 3	88	Port Authority Return	48,378
Zone 3	87	[redacted]	48,364
Zone 3	86	[redacted]	48,800
Zone 3	85	[redacted]	48,800
Zone 3	84	[redacted]	48,800
Zone 3	83	[redacted]	48,736
Zone 3	82	[redacted]	45,789
Zone 3	81	[redacted]	44,866
Zone 3	80	[redacted]	45,963
Zone 3	79	[redacted]	45,498
Zone 3	78	[redacted]	41,503
Zone 3	77	[redacted]	45,739
	75	Mechanical and Equipment Room	
Zone 2	74	Port Authority 12-31-20	47,481
Zone 2	73	Port Authority 12-31-20	47,723
Zone 2	72	Port Authority 12-31-20	47,829
Zone 2	71	Port Authority 12-31-20	47,935
Zone 2	70	Port Authority 12-31-20	48,248
Zone 2	69	Port Authority 12-31-20	47,040
Zone 2	68	Port Authority 12-31-20	46,925
Zone 2	67	Port Authority 12-31-20	47,364
Zone 2	66	Port Authority 12-31-20	47,680
Zone 2	65	Port Authority 12-31-20	47,518
Zone 2	64	Port Authority 12-31-20	47,568
Zone 2	63	Port Authority 12-31-20	46,490
Zone 2	62	Port Authority 12-31-20	46,495
Zone 2	61	Port Authority 12-31-20	46,023
Zone 2	60	[illegible] Bank 7-31-05	46,596
Zone 2	59	Brown & Wood 12-31-12	47,134
Zone 2	58	Brown & Wood 12-31-12	46,924
Zone 2	57	Brown & Wood 12-31-12	46,924
Zone 2	56	Brown & [illegible] 12-31-12	45,941
Zone 2	55	Pace Univers[illegible] 3-31-13	45,943
Zone 2	54	Brown & Wood 12-31-12	46,301
Zone 2	53	[redacted]	46,291
Zone 2	52	[redacted]	46,291
Zone 2	51	[redacted]	46,291
Zone 2	50	[redacted]	46,291
Zone 2	49	[redacted]	46,286
Zone 2	48	[redacted]	43,760

Zone	Floor	Tenant	Sq. Ft.
	57	[illegible]	[illegible]
	56	[illegible]	45,941
	55	[illegible]	45,943
	54	[illegible]	46,301
	53	Multiple Tenants	46,291
	52	[illegible] / Multiple Tenants	46,291
	51	[illegible] / Multiple Tenants	46,291
	50	[illegible] 12-31-02	46,291
	49	[illegible] 6-30-10	46,286
	48	[illegible] 3-31-10	43,760
	47	Multiple Tenants	43,343
	46	Multiple Tenants	44,034
	45	Multiple Tenants	44,003
	44	[illegible] / Port Authority Kitchen 12-31-20 / Multiple Tenants	39,001
	43	Port Authority Cafeteria 12-31-20	43,770
	41	Mechanical and Equipment Room	
Zone 1	40	Lehman Brothers 2-29-16	45,916
	39	Lehman Brothers 2-29-16 / Multiple Tenants	45,940
	38	Lehman Brothers 2-29-16	46,005
	37	[illegible]	46,116
	36	Lumbermens Mutual Casualty 6-30-13	46,116
	35	Lumbermens Mutual Casualty 6-30-23	46,116
	34	[illegible] Educational 6-30-07	45,110
	33	[illegible] / Multiple Tenants	45,110
	32	[illegible] / Multiple Tenants	45,495
	31	Empire Blue Cross 12-31-18	45,544
	30	Empire Blue Cross 12-31-18	45,544
	29	Empire Blue Cross 12-31-18	45,544
	28	Empire Blue Cross 12-31-18	45,544
	27	Empire Blue Cross 12-31-18	45,544
	26	[illegible] / Available	43,864
	25	[illegible]	45,298
	24	Empire Blue Cross 12-31-08	44,918
	23	Empire Blue Cross 12-31-18	44,978
	22	[illegible] / Multiple Tenants	44,973
	21	[illegible] / Multiple Tenants	44,973
	20	[illegible]	44,355
	19	Empire Blue Cross 12-31-18	45,029
	18	[illegible] 6-30-10	43,945
	17	Empire Blue Cross 12-31-18	43,944
	16	[illegible] Shipping Company 2-28-06	44,354
	15	[illegible]	44,383
	14	[illegible] 6-30-10	44,383
	13	[illegible] 6-30-10	44,383
	12	[illegible] 6-30-10	44,383
	11	[illegible] / Multiple Tenants	44,258
	10	[illegible] 6-30-10	44,258
	9	[illegible] 6-30-10	44,258
	7	Mechanical and Equipment Room	
	6		
	5		
	4		
	3		
		Plaza Level	
		Lobby/Concourse Level	
		Total	4,468,634



Legend:

- Port Authority
- Lobby
- Single Tenant Floors
- Amenity
- Multi-Tenant Floors
- Mechanical/Other

ATTACHMENT 6

BOCA Group International Elevator Survey Report

BOCA GROUP
INTERNATIONAL, INC.
VERTICAL TRANSPORTATION CONSULTING

December 5, 2000

Mr. Robert Weiland
Merritt & Harris, Inc.
110 East 42nd Street
Suite 1200
New York, NY 10017-5685

RE: ONE WORLD TRADE CENTER
NEW YORK, NY
Vertical Transportation Study

Dear Mr. Weiland:

We are pleased to submit our preliminary report based on a visual inspection performed by our field engineers who visited the above referenced property on and a review of the documents made available to us in the offices of the Port Authority of New York and New Jersey.

OVERVIEW, LAYOUT AND EQUIPMENT

In terms of maintenance, most types of repair or replacement of the elevator equipment is covered by the elevator contractor under the maintenance contract.

We noted one significant condition that needs to be addressed, the hoist cables on Car No. 99 has a severe rust condition. Replacement is recommended.

There is a total of 93 passenger elevators in this building, 61 cars have been modernized, 3 cars in the process of being modernized and 28 cars that are scheduled for a modernization in the near future. There are 6 freight elevators in which 2 cars have been modernized.

There are 72 local stop passenger elevators and 19 shuttle stop passenger elevators serving the floors (Lobby, 9-107). There are 2 express elevators serving Windows on the World on the 106th and 107th floors. There are 3 Elevators outside the building foot print ("J" elevators) that serve the B1 to B6 levels (Tower 1 and all subgrade spaces). The vertical transportation system is divided into 3 vertical zones serviced from the main lobby and the 2 sky lobbies, which are at the 44th and 78th floors. There are 8 shuttle elevators traveling from the lobby to the 44th floor sky lobby and 11 shuttle elevators traveling from the lobby to the 78th floor sky lobby. The main lobby and the sky lobbies each access 4 banks (A, B, C, D) of 6 passenger

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cars which provide local service to portions of their respective zones. Each local bank of 6 elevators serves approximately 8 stories.

There is one set of escalators serving the Lobby Level to the Plaza Level. There are two pairs of escalators on each sky lobby floor, serving the floors above and below. Some elevators also serve the floor above the sky lobby.

ONE WORLD TRADE CENTER

(Pre-selected elevators observed)

ELEVATOR #	FLOORS SERVED	CAPACITY	CONTRACT SPEED (FPM)	FUNCTION
17	1, 2, 3, or 4 & 44	10,000	1,600 FPM	PASS/SERVICE
4	Front 1 Rear 44	10,000	1,600 FPM	PASS
53	44-54	3,500	500 FPM	PASS
76	78-86	3,500	500 FPM	PASS
94	78, 101-107	3,500	1,000 FPM	PASS
99	Front 106-108 Rear 109-110	4,000	100	FREIGHT
8	Front 1 Rear 44	10,000	1,600	PASS

<u>ELEVATOR NO.S 76, 53, 4, 8 & 17</u>

All have Otis motor generators with Otis relay logic type controllers. All machine types are overhead gearless traction.

<u>ELEVATOR NO. 94</u>

Is driven by an SCR drive unit with CEC swift futura controllers. Machine type is overhead gearless traction.

<u>ELEVATOR NO. 99</u>

Is driven by a SCR drive unit with CEC swift futura controllers. Machine type is underslung geared overhead traction.

ESCALATORS

There are also ten (10) escalators serving this building. The following chart describes service provided by these modernized units.

UNIT #	FLOORS SERVED	RISE
A1 & A2	Concourse to Plaza	22' 0"
A3 & A4	Floors 43 to 44	12' 0"
A5 & A6	Floors 44 to 45	14' 0"
A7 & A8	Floors 77 to 78	12' 0"
A9 & A10	Floors 78 to 79	14' 0"

ELEVATOR FIVE YEAR TESTS:

ELEVATOR #	5-YEAR TEST TAG DATE	DATE OF EXPIRATION	STATUS
17	1999	2004	CURRENT
4	1999	2004	CURRENT
53	2000	2005	CURRENT
76	1996	2001	CURRENT
94	1999	2004	CURRENT
99	1997	2002	CURRENT
8	1999	2004	CURRENT

COMPLIANCE

ELEVATOR NO.S 17, 4, 53, 76, 94 and 8

All have emergency power with automatic transfer. The machine rooms have smoke detectors, the main lines are fused and lockout capable. The elevators have fire return Phase 1 and II. The elevators are fully A.D. A. complaint. All required safety tests are up to date.

ELEVATOR NO. 99

Has fire return Phase I and II. The machine rooms have smoke detectors. The elevator has emergency power with automatic transfer. The main line is fused and lockout capable. All required safety test are current.

ELEVATOR CHARTS

1 WORLD TRADE CENTER - ZONE 1

ELEVATOR #	FLOORS SERVED	CAPACITY	CONTRACT SPEED (FPM)	FUNCTION	BANK
24-29	9-16	3,500	800 FPM	PASSENGER	A
30-35	17-24	3,500	1000 FPM	PASSENGER	B
42-47	33-40	3,500	1400 FPM	PASSENGER	D
36-41	25-32	3,500	1200 FPM	PASSENGER	C
J2-J3	1, B1* - B6	4,000	250 FPM	PASSENGER	J
J1	1, B1 - B6	6,000	250 FPM	PASSENGER / FREIGHT	J
48	B1, 1, 2, 3-7, 9-40	5,000	800 FPM	FREIGHT	- -
5	B1, 1, 3, 4, 5, 7, 9-40, 44	10,000	1600 FPM	FREIGHT	- -

*KEY (LOADING DOCK)

1 WORLD TRADE CENTER

ELEVATOR #	FLOORS SERVED	CAPACITY	CONTRACT SPEED (FPM)	FUNCTION	BANK
FE8 - Cafe Freight	43-44	1,330	100 FPM	FREIGHT	SUB-GRADE
:7 - Armor Freight	Front 1 Rear B1	4,000	250 FPM	FREIGHT	
J4	1, B1	6,000	150 FPM	PASSENGER / FREIGHT	SUB-GRADE
FE5 - Hydraulic	B1-B3	7,000	100 FPM	FREIGHT	SUB-GRADE

1 WORLD TRADE CENTER - ZONE 2

ELEVATOR #	FLOORS SERVED	CAPACITY	CONTRACT SPEED (FPM)	FUNCTION	BANK
1-4	FRONT 1 REAR 44	10,000	1,600 FPM	PASSENGER	LOW RISE SHUTTLES
8-11	FRONT 1 REAR 44	10,000	1,600 FPM	PASSENGER	LOW RISE SHUTTLES
17	B1, 1, 3, 4, 5, 43-74 AND 78	10,000	1,600 FPM (runs @ 1200 FPM)	FREIGHT	- -
49	B1, 1, 3, 4, 5, 41-74	5,000	1,000 FPM	FREIGHT	- -
51-56	44-54	3500	500 FPM	PASSENGER	A
57-62	55-61	3500	800 FPM	PASSENGER	B
69-74	68-74	3500	1,000 FPM	PASSENGER	D
63-68	62-67	3500	800 FPM	PASSENGER	C

1 WORLD TRADE CENTER - ZONE 3

ELEVATOR #	FLOORS SERVED	CAPACITY	CONTRACT SPEED (FPM)	FUNCTION	BANK
6	FRONT – 1+107 REAR – B1, 1, 3, 4, 5, 44, 75,77-107	10,000	1,600 FPM	FREIGHT / PASSENGER	Shuttle for Windows
7	FRONT – 1, 106 +107 REAR – B1, C, 44, 67, 77	10,000	1,600 FPM	FREIGHT	Shuttle for Windows
12-15, 20-23	FRONT - 1 REAR – 78	10,000	1,600 FPM	PASSENGER	SHUTTLE
*16, 18, 19	FRONT – 1+44 REAR – 78	10,000	1,600 FPM	PASSENGER	SHUTTLE
50	B5 - 7, 9-108	6,000	1,200 FPM	FREIGHT	–
75-80	78-86	3,500	500 FPM	PASSENGER	A
81-86	87-93	3,500	500 FPM	PASSENGER	B
87-92	94-100	3,500	500 FPM	PASSENGER	C
93-98	100-107	3,500	1,000 FPM	PASSENGER	D
99	106-110	4,000	100 FPM	FREIGHT	–

*INTERZONE ELEVATORS

EQUIPMENT

LOCAL ELEVATORS

MODERNIZED ELEVATORS

24-47, 51, 52, 56-64, 69-74, 81, 83, 87-98 consists of CEC swift futura controllers with SCR Drive units. All machines are of the overhead gearless traction type.

ORIGINAL ELEVATORS

53, 54, 66-68, 75-80, 84-86 consists of the original Otis relay logic controller with motor generator sets. All machines are of the overhead gearless traction type.

IN PROCESS OF MODERNIZATION

Elevators 55, 65 and 82 will be CEC swift futura controllers with SCR Drive units. All machines are of the overhead gearless traction type.

LOW RISE SHUTTLES

Elevator Nos. 1-11: All original Otis relay logic controllers with motor generator sets. All overhead gearless traction machines.

HIGH RISE SHUTTLES

MODERNIZATION ELEVATORS
12-15, 6 & 7 consists of CEC Swift Futura controllers with SCR Drive units. All overhead gearless traction machines.

ORIGINAL ELEVATORS
16-23. Consists of the original Otis relay logic type controllers with motor generator sets. All being overhead gearless traction machines. No freight elevators in process of modernization.

FREIGHT ELEVATORS

J1-J4
Consists of original Otis relay logic controllers with motor generator sets. Machine type is basement geared traction.

5,48, 17, 49,
All original Otis relay type controllers with original motor generator sets. All machines being overhead gearless traction.

50
Modernized with a CEC Swift Futura controller with the original motor generator set. All machines being overhead gearless traction.

FE7 & FE8

Consists of original Otis relay type controllers with original motor generator sets. All machines being overhead geared traction.

6, 7, 99
Modernized with CEC Swift Futura controllers. Elevator No. 99 has an SCR drive unit with an offset overhead underslung traction machine. Elevator Nos. 6 and 7 have motor generator sets with overhead gearless traction machines.

If you have any questions, please do not hesitate to contact us.

Sincerely,

BOCA Group International, Inc.

Robert Werner

Robert Wernon
Field Engineer
ONE World Trade Ctr Vert Trans Study 11-1-00.doc

BOCA GROUP
INTERNATIONAL, INC.
VERTICAL TRANSPORTATION CONSULTING

December 5, 2000

Mr. Robert Weiland
Merritt & Harris, Inc.
110 East 42nd Street
Suite 1200
New York, NY 10017-5685

Re: **WORLD TRADE CENTER**
NEW YORK, NY
Building One
Theoretical Traffic Analysis

Dear Mr. Brady:

The following are the criteria and a summary of the results of our calculated elevator traffic analysis for One World Trade Center:

CRITERIA

The following are the criteria used to analyze elevator traffic capabilities:

- **Maximum Five-minute Handling Capacity (# of People):** This is the approximate maximum number of passengers the elevator system can be expected to serve during a five-minute peak period. For a bank of elevators serving commercial office space, this should be no less than 10% to 12% of the total population this bank is expected to serve.

- **Maximum Five-minute Handling Capacity (% of Population):** This is the percentage of the total expected population served by the elevator bank represented by the maximum five-minute handling capacity. For a bank of elevators serving commercial office space, this should be no less that 10% to 12

- **Average Interval:** This is the average time interval between elevators passing a given floor in a particular direction during a peak period, assuming the elevators are evenly spaced throughout the building. Note that Average Interval is a design criteria, and is NOT the same as the "average waiting time", which cannot be directly calculated by theoretical means. For a bank of elevators serving commercial office space, the average interval should be no more than 35 to 45 seconds.

NEW YORK • TAMPA • LAS VEGAS • SAN FRANCISCO
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TELEPHONE (212) 983-7010 • FAX (212) 983-7011 • E-MAIL info@bocagroup.com
www.bocagroup.com

SUMMARY OF RESULTS

SHUTTLES

- The Zone 2 shuttle can achieve a maximum handling capacity of 18% of the population they serve, with an average interval of 25 seconds.
- The Zone 3 shuttle can achieve a maximum handling capacity of 22% of the population they serve, with an average interval of 22 seconds.

LOCAL BANKS

- The results for the local banks (A, B, C, D of any zone) can achieve maximum handling capacities ranging between 13-18% and average intervals of approximately 30 seconds.

The results described above show that the elevators in One World Trade Center should provide acceptable service during peak traffic periods with a full population in the buildings.

Should you have any questions or should you need any clarifications on our report, please feel free to contact us. Thank you.

Sincerely,

BOCA GROUP INTERNATIONAL, INC.

Daniel DeBlasio

Daniel DeBlasio
Director of Engineering
World Trade Center - 1 Traffic Analysis doc

ATTACHMENT 7

Crandlemere and Associates Asbestos-Containing Materials
Document Review & Evaluation

R. W. CRANDLEMERE & ASSOCIATES, INC.
PROTECTING BUSINESS AND THE ENVIRONMENT

ASBESTOS-CONTAINING MATERIALS

DOCUMENT REVIEW AND EVALUATION

ONE WORLD TRADE CENTER, NORTH TOWER

NEW YORK CITY, NY 10081

Project #000095

Merritt & Harris, Inc. #20-251E

User:

Merritt & Harris, Inc.
Attn: Mr. Robert G. Weiland, V. P.
110 East 42nd Street, 12th Floor
New York City, NY 10017-5685

Date Issued: November 7, 2000

549 Columbian Street, Suite 305, Weymouth, MA 02190 Tel. (781) 340-6161 Fax (781) 340-9191

The Asbestos-Containing Materials Document Review and Evaluation described herein was conducted by the undersigned, of R. W. Crandlemere & Associates, Inc. (CRANDLEMERE & ASSOCIATES). CRANDLEMERE & ASSOCIATES assessment consisted solely of the activities described in the Introduction of this report. The assessment was conducted in accordance with the Scope of Work in our Proposal No 00-090. It is subject to the Limitations and Service Constraints as provided in Appendix A of our ASTM Phase I Environmental Site Assessment report prepared as part of this Project. See Appendix F of that report for ASTM definition of terms in italics in this report.

Report Prepared by:

R. Wayne Crandlemere
President

TABLE OF CONTENTS

1.0 INTRODUCTION

R. W. Crandlemere & Associates, Inc. (CRANDLEMERE & ASSOCIATES) was retained by Merritt & Harris, Inc. (the *user*) to conduct an ASTM E1527-97 Phase I *Environmental Site Assessment* (ESA) of One, Two, Four and Five World Trade Center, located in the Borough of Manhattan, New York City, New York, 10081.

It is our understanding that Merritt & Harris, Inc. is providing this information in conjunction with, and as part of, a larger assessment of the *property* and has named The Port Authority of New York and New Jersey as an *additional user* as defined by the ASTM Standard E1527-97 Section 3.3.39. As an *additional user*, The Port Authority of New York and New Jersey may rely on the information presented in this report.

This report presents CRANDLEMERE & ASSOCIATES' professional opinion, and no warranty, expressed or implied, is made. The Port Authority of New York and New Jersey has the right to reproduce in full and provide copies of this report to interested parties. All reports, both verbal and written, are for the benefit of The Port Authority of New York and New Jersey and its' agents, employees, participates, and assigns.

On September 26, 27, 28 and 29 and October 10 and 11, 2000 Mr. R. Wayne Crandlemere of CRANDLEMERE & ASSOCIATES conducted a *Site visit* to identify *recognized environmental conditions* at the Site. In addition, CRANDLEMERE & ASSOCIATES' assessment included reconnaissance of adjacent properties, background research, and review of available local, state and federal regulatory records regarding the presence of petroleum products or hazardous materials at or in the vicinity of the Site.

The results of our work regarding the ASTM Standard for a Phase I Environmental Site Assessment of the Site is provided in a separate Phase I ESA report.

This report addresses the asbestos-containing materials (ACM) related to the One World Trade Center, North Tower (including elevator, façade, and asbestos issues for this building). See the separate reports specifically related to the Two World Trade Center, Four World Trade Center, Five World Trade Center, Retail Mall and Plaza, Central Services and Subgrade for ACM information specific to those buildings and facility areas.

1.1 Background

The World Trade Center was constructed between 1966 and 1970 when asbestos was used in buildings as a fire retardant. According to the World Trade Center Property Book (see Section 3.4), "sprayed on asbestos is present within the 6th floor catwalks, mezzanine substructure, elevator shafts and machine rooms, interior core pipe chases, and electric and phone closets of the Twin Tower buildings. Additionally, asbestos-containing thermal system pipe insulation is present in pipe chases, the Concourse ceiling plenum and in MERs [mechanical equipment rooms], while vinyl asbestos floor tiles are present throughout the complex. The Port Authority has removed a large portion of the asbestos material typically located on the structural columns and on pipe insulation from tenant

floors in One World Trade Center, and has removed much of the pipe wrap insulation found in the Subgrade. The practice of containment has not been implemented at the World Trade Center."

"In addition to full-scale abatement projects, the World Trade Center has instituted an ongoing operations and maintenance program whereby specific individuals on the staff are trained as certified ACM handlers and can respond with appropriate equipment and procedures to manage incidental ACM incidents. Tenants whose space may contain ACM have been formally notified."

1.2 Scope of Work

Beyond the Scope of Work for the ASTM Standard for a Phase I Environmental Site Assessment, but as required by the *user*, summaries of readily available information (provided by and apparently prepared by the Port Authority of New York and New Jersey) pertaining to the presence of asbestos-containing building materials (ACBM) and documentation of the work done to abate ACBM was evaluated. No sampling or analysis was included and this is not to be interpreted as a complete asbestos survey.

Please note: There is reported litigation in progress for cost-recovery of money related to ACM abatement and/or management. This litigation was not evaluated as part of this assessment and the *user* should consider a detailed review of the on-going litigation and make their own determination as to the impact, if any, on their use of this report and/or future impact of the litigation on their decision making process related to the World Trade Center. Further, the information presented in this report is based at least in part on a somewhat arbitrary separation of areas of the complex that may or may not have any basis in the current operation of the Complex as it is currently managed as one facility. The *user* should consider this report as a good faith effort to present ACM related information to the subject area, however, the *user* is encouraged to review the ACM related Section of the Phase I Environmental Site Assessment (ESA) report which provides a summary of all ACM related information provided by the *owner*. Included in Appendix H-7 of the ESA report are copies of the asbestos program highlights as presented in the World Trade Center Environmental Programs 1999 Year End report. This includes a summary of 1999 Asbestos Projects, World Trade Center Asbestos Disclosure, World Trade Center Elevator Shaft Asbestos Assessment, and World Trade Center Asbestos Contract Administration procedures. Portions of those documents are included in this report. Additionally, the *user* should consider an independent review of the information provided.

It should also be noted that certain materials such as fire doors were not included in the materials suspected to be asbestos-containing and have not been tested or otherwise investigated. It was reported that testing of spline ceilings, hung ceilings, wallboard and wallboard joint compound determined that they were not ACM throughout the facility. A review of test results was not performed and we cannot verify the adequacy of such testing. The *user* may wish to further investigate such materials.

There have been significant on-going asbestos abatement projects and cost estimates provided by the *owner* indicate the following estimated removal costs:

Material	Removal Cost
Vinyl asbestos tile (VAT)	$ 5-6/square foot
Sprayed-on Fireproofing	$20-25/square foot
Thermal System Insulation (TSI)	$15/linear foot

The actual costs for VAT removal for 1999 projects are provided in Appendix H-7 of the Phase I ESA report.

Documentation regarding the presence of ACM in elevator shafts is presented by shaft designation. It is unclear where the shafts are located within the facility and the *user* should consider cross-referencing the shaft locations to the area under consideration. Mr. Taylor reported that there are forty (40) shafts that contain ACM within the Center.

2.0 SUMMARY OF REVIEW OF DOCUMENTS

Materials known to be present in One World Trade Center (excluding mechanical equipment rooms, truck dock and Subgrade locations) appear to include:

Material	Amount
Spray-on fireproofing	124,888 square feet
Cementitious insulation behind convector units	60 square feet
Thermal system insulation (TSI)	1,430 linear feet
Exhaust duct insulation	1,000 linear feet
Elevator pits and shafts	As noted in documents
Vinyl asbestos tile (VAT)	710,677 Square feet

Additionally, the following ACM was reported:

Mechanical Equipment Rooms	100,000 square feet spray-on fireproofing and unknown quantities of TSI
Level B-1; Cove and Northeast quadrant	5,000 square feet spray-on fireproofing/No TSI
Level B-6	40,000 square feet spray-on fireproofing/No TSI
Roof	Could contain asbestos

1 WTC

Excluding MERs, Truckdock, and Subgrade Locations

Location	Floors	Amount
Floors with less than 160 sqft* of sprayed-on fireproofing:	43 Floors	6,880 sqft
TOTAL:		6,880 sqft

** Classified as "Random Locations On Floor" in WTC Disclosure Memorandum*

Floors with less than 10 sqft of cementitious insulation behind convector units*:	6 Floors	60 sqft
TOTAL:		60 sqft

** Classified as "Convector Units" in the WTC Disclosure Memoradum*

Full Floor Locations:

Core Floors 1 – 5 / 35,000sqft of sprayed-on fireproofing:	5 Floors	175,000 sqft
6th Floor Plus Catwalk	1 Floor	35,000 sqft
Lobby Mezzanine	Mezzanine	15,000 sqft
	TOTAL:	231,940 sqft

** Classified as "Full Floor Locations" in the WTC Disclosure Memorandum*

PA Café Kitchen Exhasut Duct	2 Floors	1,000 lnft
Thermal System Insulation On Vertical Steam Line:	B6 – 108th Floor	1,430 lnft
	TOTAL:	2,430 lnft

WILL INCLUDE VAT FIGURES

THE PORT AUTHORITY OF NY & NJ **Memorandum**

TO: Joanne Ciccollo
FROM: Joe Amatuccio
DATE: September 27, 2000

SUBJECT: ASBESTOS DISCLOSURE:
One World Trade Center: 33rd and 34th Floors.

COPY: A. Burton, T. Lynch, E. Monteverde, P. Taylor, F. Varriano, L. Zucchi

Regarding your inquiry as to the presence of asbestos-containing building materials present on the 33rd and 34th floors in One World Trade Center, our site survey and bulk sampling data base indicates the following:

On the 33rd floor, there is no asbestos-containing sprayed-on fireproofing or thermal system insulation material present, as defined by the U.S. Environmental Protection Agency standard 40 CFR Part 61: National Emissions Standard For Hazardous Air Pollutants; Asbestos – Final Rule and the U.S. Occupational Safety and Health Administration standard 29 CFR 1910.1001: Asbestos, within the leasehold area. Asbestos-containing sprayed-on fireproofing is however present behind the core walls, but not the within the core's plenum. Vinyl asbestos floor tiles have been identified on the northwest quadrant of the floor.

On the 34th floor, there is no asbestos-containing sprayed-on fireproofing or thermal system insulation material present, as defined by the U.S. Environmental Protection Agency standard 40 CFR Part 61: National Emissions Standard For Hazardous Air Pollutants; Asbestos – Final Rule and the U.S. Occupational Safety and Health Administration standard 29 CFR 1910.1001: Asbestos, within the leasehold area. Asbestos-containing sprayed-on fireproofing is however present behind the core walls, but not the within the core's plenum. There is are no vinyl asbestos floor tile present.

Should you have any questions, please contact me at x 2704.

Joe Amatuccio
Manager,
Operations & Maintenance Management

THE PORT AUTHORITY OF NY & NJ MEMORANDUM

TO:	Joseph Amatuccio, Carla Bonacci, Jerrold Dinkels, Frank DiMartini, Eric Hauser, Louis Menno, Edwin Monteverde, Francis Riccardelli, Nancy Seliga
FROM:	John Castaldo
DATE:	September 19, 2000
SUBJECT:	**ASBESTOS POSITIVE LOCATIONS AT THE WORLD TRADE CENTER: UPDATE.**
REFERENCE:	J. Castaldo to Addressees; Memorandums Dated 5/4/98 and 12/21/99; Same Subject.
COPY:	L. Ardizzone, S. Benjamin, I. Chachkes, J. Connors, W. Devlin, M. Finegold, M. Hurley, M. Jakubek, M. Kirshner, T. Lynch, U. Mehta, G. Meyer, R. Muessig, C. Nanninga, A. Reiss, E. Strauss, G. Tabek, P. Taylor, F. Varriano, L. Zucchi, Operations Control Desk, S-4's

Attached please find an update to my initial May, 1998 memorandum wherein the known asbestos locations at the World Trade Center were disclosed. The information provided in this disclosure is a compulation of avaliable bulk sampling and analytical results from both the World Trade and Engineering Departments' data bases.

In compliance with the disclosure requirements of the U.S. Occupational Safety and Health Administration's asbestos standard, I am requesting that this information be distributed to all World Trade Department, Engineering Department, PA Office Space, and Leasing Division property managers, project managers, construction managers, construction inspectors, operations supervisors, security supervisors, facility maintanence supervisors, and leasing agents associated with the allocation of space, and the design and implementation of World Trade Center projects. Additionally, please forward this information to those contractors under your administration. If there are questions as to the presence of asbestos-containing materials at a particular location, or if the scope of demolition and/or renovation work may impact asbestos-containing materials, please contact Art Burton, Assistant Environmental Coordinator, at 435-8364.

Those on the copyline are requested to contact this office for the appropriate response action if asbestos-containing materials may be impacted by work under your jurisdiction. The Port Authority complies with Industrial Code Rule #56 relative to worker certifications, contractor licensing, and work procedures if asbestos is going to be disturbed or impacted. Please contact me at 435-8518 should you have any questions.

John Castaldo
General Manager,
Base Building Services

Asbestos-Containing Surfacing And/Or Thermal System Insulation Materials Located In One World Trade Center - Exclusive Of Elevator Shafts

Full Floor Locations

- Lobby Mezzanine
- 1st - 6th Floors: Core
- 6th Floor Catwalk
- 7th / 8th Floor MER
- 41st / 42nd Floor MER
- 75th / 76th Floor MER
- 108th / 109th Floor MER

Random Locations On Floor

- 43rd / 44th Floor PA Exhaust Duct
- 82nd Floor
- 104th Floor
- Core Electric Closets On The 1st – 40th floors
- Perimeter Electric Closets On The 30th Floor

Subgrades

- B1 Level:
- Core, N/E Quadrant
- B6 Level

Convector Units

- 77th Floor
- 79th Floor
- 88th Floor
- 101st Floor
- 103rd Floor
- 105th floor

Asbestos-Containing Surfacing And/Or Thermal System Insulation Materials Located In Two World Trade Center - Exclusive Of Elevator Shafts

Full Floor Locations

- 6th Floor Catwalk
- 10th – 13th Floors (Bell Atlantic)
- 41st / 42nd Floor MER

Random Locations On Floor

- Lobby Mezzanine
- 7th / 8th Floor MER
- 9th Floor
- 19th Floor
- 20th Floor
- 26th Floor
- 33rd Floor
- 71st Floor
- 75th / 76th Floor MER

Quadrant Location

- S/W, 43rd Floor Kitchen Exhaust Duct

Convector Units

- 22nd Floor
- 24th Floor
- 59th Floor
- 72nd Floor
- 79th Floor
- 81st Floor
- 84th Floor
- 86th Floor
- 87th Floor

World Trade Center Elevator Shafts With Asbestos-Containing Surfacing Insulation Material

<u>One World Trade Center</u>

Pits and Shafts

1 / 2	39 / 40 / 41
3 / 4	42 / 43 / 44
5 / 48	45 / 46 / 47
8 / 9	51 / 52 / 53
16 /17	54 / 55 / 56
49	57 / 58 / 59
18 / 19	60 / 61 / 62
20 / 21	63 / 64 / 65
22 / 23	66 / 67 / 68
50	69 / 70 / 71
24 / 25 / 26	72 / 73 / 74
27 / 28 / 29	
30 / 31 / 32	
33 / 34 / 35	
36 / 37 / 38	

<u>Two World Trade Center</u>

Pits and Shafts

5 / 48	36 / 37 / 38
10 / 11	39 / 40 / 41
14 / 15	42 / 43 / 44
24 / 25 / 26	45 / 46 / 47
27 / 28 / 29	54 / 55 / 56
30 / 31 / 32	57 / 58 / 59
33 / 34 / 35	63 / 64 / 65

There is no asbestos-containing surfacing insulation material in the J and K elevator cars in 1 and 2 WTC.

There is no asbestos-containing surfacing insulation material with the elevator shafts in 4 and 5 WTC.

Asbestos-Containing Surfacing And/Or Thermal System Insulation Materials Located In Four And Five World Trade Center

There is no asbestos-containing sprayed-on fireproofing in Four and Five World Trade Center.
A cementitious patch has been identified on a beam in the south wing of the southwest portion on the 5th floor in 5 WTC.
Thermal system insulation is present in the form of pipe saddles.

Asbestos-Containing Surfacing And/Or Thermal System Insulation Materials Located On The Concourse

There is no asbestos-containing sprayed-on fireproofing in the plenum of the Concourse.
Thermal system insulation material is present.
ACM

Asbestos-Containing Surfacing And/Or Thermal System Insulation Materials Located On The B1 Level And The Truckdock

Asbestos-containing sprayed-on fireproofing and thermal system insulation material is present.

Miscellaneous Asbestos-Containing Materials At The World Trade Center

Base building flooring throughout the facility is vinyl asbestos floor tile (VAT).

Asbestos-Containing Surfacing And Thermal System Insulation Materials Located In One World Trade Center - Exclusive Of Elevator Shafts

Full Floor Locations	Quadrant Location	Random Locations On Floor	Subgrades
Lobby Mezzanine 1st - 6th Floors: Core 6th Floor Catwalk 7 / 8 Floor MER 41 / 42 Floor MER 75 / 76 Floor MER 108 / 109 Floor MER		43 / 44 Floor Exhaust Duct 72nd Floor 82nd Floor Core Electric Closets On The 1st - 40th Floors Perimeter Electric Closet On The 30th Floors	B1 Level: Core, North/ West/East Quadrant, B2 Level: Old Locksmith And B6 Level

Asbestos-Containing Surfacing And Thermal System Insulation Materials Located In Two World Trade Center - Exclusive Of Elevator Shafts

Full Floor Locations	Random Locations On Floor	Quadrant Location
6th Floor Catwalk 10th - 13th Floors 41 / 42 Floor MER	Lobby Mezzanine 7 / 8 Floor MER 9th Floor 19th Floor 20th Floor 26th Floor 33rd Floor 71st Floor 75 / 76 Floor MER	S/W, 43rd Floor

Asbestos-Containing Surfacing And Thermal System Insulation Materials Located In Four And Five World Trade Center

There is no asbestos-containing sprayed-on fireproofing in Four and Five World Trade Center.
Thermal system insulation is present in the form of pipe saddles.

Asbestos-Containing Surfacing And Thermal System Insulation Materials Located On The Concourse

There is no asbestos-containing sprayed-on fireproofing in the plenum of the Concourse.
There is thermal system insulation material present.
ACM

Asbestos-Containing Surfacing And Thermal System Insulation Materials Located On The B1 Level And The Truckdock

Asbestos-containing sprayed-on fireproofing and thermal system insulation material is present.

Miscellaneous Asbestos-Containing Materials At The World Trade Center

Base building flooring throughout the facility is vinyl asbestos floor tile (VAT).

ACBM is located behind the convector units at the following locations:
1 WTC; 77, 79, 88, 101, 103 and 105.
2 WTC; 22, 24, 59, 72, 79, 81, 84, 86 and 87.

World Trade Center Elevator Shafts With Asbestos-Containing Insulation Material

One World Trade Center

Shafts		
Shafts	1 - 5:	Elevator Pit to EMR
	8 - 9:	Elevator Pit to EMR
	16 - 21:	Elevator Pit to 32nd Floor
	22 - 23:	Elevator Pit to EMR
	48:	Elevator Pit to EMR
	49:	Elevator Pit to 32nd Floor
	50:	Elevator Pit to 31st Floor
	24 - 29:	Elevator Pit to EMR
	30 - 35:	Elevator Pit to EMR
	36 - 41:	Elevator Pit to EMR
	42 - 47:	Elevator Pit to EMR
	51 - 56:	Elevator Pit to EMR
	57 - 62:	Elevator Pit to EMR
	63 - 68:	Elevator Pit to EMR
	69 - 74:	Elevator Pit to EMR

Two World Trade Center

Shafts	5 & 48:	Elevator Pit to EMR
	10 & 11:	Elevator Pit to EMR
	14 & 15:	Elevator Pit to EMR
	24 - 29:	Elevator Pit to EMR
	30 - 35:	Elevator Pit to EMR
	36 - 41:	Elevator Pit to EMR
	42 - 47:	Elevator Pit to EMR
	51 - 56:	Elevator Pit to EMR
	57 - 62:	Elevator Pit to EMR
	63 - 68:	Elevator Pit to EMR
	69 - 74:	Elevator Pit to EMR

There is no asbestos-containing insulation material in the J and K elevator cars in 1 and 2 WTC.

There is no asbestos-containing insulation material with the elevator shafts in 4 and 5 WTC.

THE PORT AUTHORITY OF NEW YORK & NEW JERSEY

MEMORANDUM

TO: Phil Taylor-Supervising Engineer.

FROM: Pete Negron

DATE: July 21, 1999

SUBJECT: **Elevator Shaft Asbestos Assessment.**

REFERENCE: **Attached E-Mall**

COPY TO: J. Amatuccio, D. Bobbitt, A. Burton, J. Castaldo, F. Riccardelli, L. Zucchi.

During the week of July 21, 1999, I inspected the elevator shafts to assess the condition of the fireproofing on the steel members.

The attached report includes the shaft number, floor and condition of fireproofing: intact or delaminated, and recommended action.

Floors not listed were inspected and found to be acceptable in that the fireproofing was intact.

In summary, of the 22 shafts inspected, shafts, which require full-scale abatement, are shafts 22/23A, 10B and 48B.

If you require further information regarding this report please contact me at 1.212.435.8364.

Pete Negron
Associate Environmental Analyst
Operations & Maintenance Management
World Trade Center

Attachment

WORLD TRADE CENTER
ELEVATOR SHAFTS ASBESTOS ASSESSMENT

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
25	1A	NO	YES	24 S.F.	SEAL EDGES
26	1A	NO	YES	12 S.F.	SEAL EDGES
27	1A	NO	YES	30 S.F.	SEAL EDGES
28	1A	NO	YES	12 S.F.	SEAL EDGES
29	1A	NO	YES	48 S.F.	SEAL EDGES
SPRAY-ON MATERIAL					

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
9	2A	NO	YES	24 S.F.	SEAL EDGES
27	2A	NO	YES	4 S.F.	SEAL EDGES
28	2A	NO	YES	4 S.F.	SEAL EDGES
29	2A	NO	YES	4 S.F.	SEAL EDGES
30	2A	NO	YES	24 S.F.	SEAL EDGES
31	2A	NO	YES	24 S.F.	SEAL EDGES
34	2A	NO	YES	36 S.F.	SEAL EDGES
38	2A	NO	YES	6 S.F.	SEAL EDGES
SPRAY-ON MATERIAL					

2A

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
310	3A	NO	YES	72 S.F.	SEAL EDGES
5	3A	NO	YES	34 S.F.	SEAL EDGES
8	3A	NO	YES	48 S.F.	SEAL EDGES
9	3A	NO	YES	48 S.F.	SEAL EDGES
16	3A	NO	YES	30 S.F.	SEAL EDGES
17	3A	NO	YES	48 S.F.	SEAL EDGES
18	3A	NO	YES	48 S.F.	SEAL EDGES
19	3A	NO	YES	72 S.F.	SEAL EDGES
28	3A	NO	YES	48 S.F.	SEAL EDGES
34	3A	NO	YES	72 S.F.	SEAL EDGES
40	3A	NO	YES	6 S.F.	SEAL EDGES
SPRAYED-ON MATERIAL					

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
ALL	4A	YES	NO	NONR	NONE
CEMENTITIOUS MATERIAL					

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
ALL	5A	YES	NO	NONE	NONE
ALL	48A	YES	NO	NONE	NONE
CEMENTITIOS MATERIAL					

Note: Delamination is fireproofing whether sprayed or troweled no longer present on the steel members.

WORLD TRADE CENTER
ELEVATOR SHAFTS ASBESTOS ASSESSMENT

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
22	8A	NO	YES	72 S.F.	SEAL EDGES
33	8A	NO	YES	48 S.F.	SEAL EDGES
38	8A	NO	YES	4 S.F.	SEAL EDGES
38	8A	NO	YES	48 S.F.	SEAL EDGES
39	8A	NO	YES	48 S.F.	SEAL EDGES
SPRAY-ON MATERIAL					

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
7	9A	NO	YES	2 S.F.	SEAL EDGES
13	9A	NO	YES	2 S.F.	SEAL EDGES
24	9A	NO	YES	3 S.F.	SEAL EDGES
31	9A	NO	YES	4 S.F.	SEAL EDGES
34	9A	NO	YES	6 S.F.	SEAL EDGES
36	9A	NO	YES	8 S.F.	SEAL EDGES
39	9A	NO	YES	48 S.F.	SEAL EDGES
41	9A	NO	YES	48 S.F.	SEAL EDGES
43	9A	NO	YES	48 S.F.	SEAL EDGES
SPRAYED-ON MATERIAL					

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
9	16A	NO	YES	24 S.F.	SEAL EDGES
25	16A	NO	YES	18 S.F.	SEAL EDGES
26	16A	NO	YES	28 S.F.	SEAL EDGES
27	16A	NO	YES	48 S.F.	SEAL EDGES
28	16A	NO	YES	24 S.F.	SEAL EDGES
CEMENTITIUOS MATERIAL					

FLOORS	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
ALL	17A	YES	NO	NO	NONE

FLOORS	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
ALL	18A	X	NO	NONE	NONE

Note: Delamination is fireproofing whether sprayed or troweled no longer present on the steel members.

WORLD TRADE CENTER
ELEVATOR SHAFTS ASBESTOS ASSESSMENT

FLOOR	SHAFT 1 WTC	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
8	19A	NO	YES	16 S.F.	SEAL EDGES
10	19A	NO	YES	24 S.F.	SEAL EDGES
11	19A	NO	YES	24 S.F.	SEAL EDGES
19	19A	NO	YES	48 S.F.	SEAL EDGES
25	19A	NO	YES	48 S.F.	SEAL EDGES
26	19A	NO	YES	48 S.F.	SEAL EDGES
28	19A	NO	YES	24 S.F.	SEAL EDGES
30	19A	NO	YES	24 S.F.	SEAL EDGES
32	19A	NO	YES	2 S.F.	SEAL EDGES
CEMENTITIOUS MATERIAL					

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
8	20A	NO	YES	12 S.F.	SEAL EDGES
10	20A	NO	YES	3 S.F.	SEAL EDGES
22	20A	NO	YES	3 S.F.	SEAL EDGES
23	20A	NO	YES	3 S.F.	SEAL EDGES
25	20A	NO	YES	36 S.F.	SEAL EDGES
26	20A	NO	YES	34 S.F	SEAL EDGES
27	20A	NO	YES	26 S.F.	SEAL EDGES
28	20A	NO	YES	30 S.F.	SEAL EDGES
29	20A	NO	YES	28 S.F.	SEAL EDGES
SPRAYED-ON MATERIAL					

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
310	21A	NO	YES	24 S.F.	SEAL EDGES
2	21A	NO	YES	24 S F.	SEAL EDGES
3	21A	NO	YES	24 S.F.	SEAL EDGES
9	21A	NO	YES	24 S.F.	SEAL EDGES
23	21A	NO	YES	24 S.F.	SEAL EDGES
29	21A	NO	YES	48 S.F.	SEAL EDGES
32	21A	NO	YES	6 S.F.	SEAL EDGES
SPRAYED-ON MATERIAL					

Note: Delamination is fireproofing whether sprayed or troweled no longer present on the steel members.

WORLD TRADE CENTER
ELEVATOR SHAFTS ASBESTOS ASSESSMENT

FLOOR	SHAFT	FIREPRDOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
3	22A	NO	YES	4 S.F.	SEAL EDGES
4	22A	ND	YES	4 S.F.	SEAL EDGES
5	22A	NO	YES	4 S.F.	SEAL EDGES
6	22A	ND	YES	4 S.F.	SEAL EDGES
7	22A	NO	YES	4 S.F.	SEAL EDGES
8	22A	NO	YES	4 S.F.	SEAL EDGES
9	22A	NO	YES	4 S.F.	SEAL EDGES
10	22A	NO	YES	4 S.F.	SEAL EDGES
11	22A	NO	YES	4 S.F.	SEAL EDGES
12	22A	NO	YES	4 S.F.	SEAL EDGES
13	22A	NO	YES	4 S.F.	SEAL EDGES
14	22A	NO	YES	6 S.F.	SEAL EDGES
15	22A	NO	YES	4 S.F.	SEAL EDGES
16	22A	NO	YES	12 S.F.	SEAL EDGES
18	22A	NO	YES	6 S.F.	SEAL EDGES
19	22A	NO	YES	6 S.F.	SEAL EDGES
20	22A	NO	YES	6 S.F.	SEAL EDGES
21	22A	NO	YES	6 S.F.	SEAL EDGES
22	22A	NO	YES	6 S.F.	SEAL EDGES
23	22A	NO	YES	6 S.F.	SEAL EDGES
24	22A	NO	YES	6 S.F.	SEAL EOGES
25	22A	NO	YES	6 S.F.	SEAL EDGES
26	22A	NO	YES	8 S.F.	SEAL EDGES
27	22A	NO	YES	6 S.F.	SEAL EDGES
28	22A	NO	YES	48 S.F.	SEAL EDGES
29	22A	NO	YES	6 S.F.	SEAL EOGES
30	22A	NO	YES	6 S.F.	SEAL EDGES
31	22A	NO	YES	6 S.F.	SEAL EDGES
32	22A	NO	YES	6 S.F.	SEAL EDGES
33	22A	NO	YES	6 S.F.	SEAL EDGES
34	22A	NO	YES	6 S.F.	SEAL EDGES
35	22A	NO	YES	4 S.F.	SEAL EDGES
36	22A	NO	YES	8 S F	SEAL EOGES
37	22A	NO	YES	6 S.F	SEAL EDGES
38	22A	NO	YES	6 S.F.	SEAL EDGES
39	22A	NO	YES	24 S F.	SEAL EDGES
40	22A	NO	YES	8 S F.	SEAL EDGES
41	22A	NO	YES	8 S F.	SEAL EDGES
42	22A	NO	YES	8 S.F.	SEAL EDGES
43	22A	ND	YES	8 S.F.	SEAL EDGES
44	22A	NO	YES	8 S.F.	SEAL EOGES
45	22A	NO	YES	8 S F.	SEAL EDGES
46	22A	NO	YES	8 S.F.	SEAL EDGES
47	22A	NO	YES	8 S.F.	SEAL EDGES
48	22A	NO	YES	2 S.F.	SEAL EDGES
49	22A	NO	YES	6 S F.	SEAL EDGES
50	22A	NO	YES	2 S.F.	SEAL EDGES
51	22A	NO	YES	4 S.F.	SEAL EDGES
52	22A	NO	YES	4 S.F.	SEAL EDGES
54	22A	NO	YES	4 S.F.	SEAL EDGES
55	22A	NO	YES	2 S.F.	SEAL EDGES
56	22A	NO	YES	48 S.F.	SEAL EDGES
58	22A	NO	YES	3 S.F.	SEAL EDGES
62	22A	NO	YES	2 S.F.	SEAL EDGES
64	22A	NO	YES	2 S.F.	SEAL EDGES
67	22A	NO	YES	2 S.F.	SEAL EDGES

Note: Delamination is fireproofing whether sprayed or troweled no longer present on the steel members.

WORLD TRADE CENTER
ELEVATOR SHAFTS ASBESTOS ASSESSMENT

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
70	22A	NO	YES	3 S.F.	SEAL EDGES
73	22A	NO	YES	2 S.F.	SEAL EDGES
78	22A	NO	YES	2 S.F.	SEAL EDGES
SPRAYED-ON MATERIAL			ABATEMENT OF SHAFT IS RECOMMENDED		

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
16	23A	NO	YES	2 S.F.	SEAL EDGES
17	23A	NO	YES	2 S.F.	SEAL EDGES
18	23A	NO	YES	2 S.F.	SEAL EDGES
19	23A	NO	YES	2 S.F.	SEAL EDGES
20	23A	NO	YES	2 S.F.	SEAL EDGES
21	23A	NO	YES	2 S.F.	SEAL EDGES
22	23A	NO	YES	2 S.F.	SEAL EDGES
23	23A	NO	YES	2 S.F.	SEAL EDGES
24	23A	NO	YES	2 S.F.	SEAL EDGES
25	23A	NO	YES	2 S.F.	SEAL EDGES
26	23A	NO	YES	2 S.F.	SEAL EDGES
27	23A	NO	YES	2 S.F.	SEAL EDGES
28	23A	NO	YES	2 S.F.	SEAL EDGES
29	23A	NO	YES	2 S.F.	SEAL EDGES
30	23A	NO	YES	2 S.F.	SEAL EDGES
31	23A	NO	YES	2 S.F.	SEAL EDGES
32	23A	NO	YES	2 S.F.	SEAL EDGES
33	23A	NO	YES	2 S.F.	SEAL EDGES
34	23A	NO	YES	2 S.F.	SEAL EDGES
35	23A	NO	YES	2 S.F.	SEAL EDGES
36	23A	NO	YES	2 S.F.	SEAL EDGES
37	23A	NO	YES	2 S.F.	SEAL EDGES
73	23A	NO	YES	1 S.F.	SEAL EDGES
SPRAYED-ON MATERIAL			ABATEMENT OF SHAFT IS RECOMMENDED		

Note: Delamination is fireproofing whether sprayed or troweled no longer present on the steel members.

WORLD TRADE CENTER
ELEVATOR SHAFTS ASBESTOS ASSESSMENT

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
3	10B	NO	YES	6 S.F.	SEAL EDGES
4	10B	NO	YES	6 S.F.	SEAL EDGES
7	10B	NO	YES	8 S.F.	SEAL EDGES
12	10B	NO	YES	1 S.F.	SEAL EDGES
15	10B	NO	YES	2 S.F.	SEAL EDGES
19	10B	NO	YES	20 S.F	SEAL EDGES
20	10B	NO	YES	15 S.F.	SEAL EDGES
21	10B	NO	YES	26 S.F.	SEAL EDGES
22	10B	NO	YES	28 S.F.	SEAL EDGES
23	10B	NO	YES	15 S.F.	SEAL EDGES
25	10B	NO	YES	48 S.F.	SEAL EDGES
28	10B	NO	YES	4 S.F.	SEAL EDGES
29	10B	NO	YES	2 S.F.	SEAL EDGES
31	10B	NO	YES	2 S.F.	SEAL EDGES
34	10B	NO	YES	48 S.F.	SEAL EDGES
35	10B	NO	YES	48 S.F.	SEAL EDGES
36	10B	NO	YES	34 S.F.	SEAL EDGES
37	10B	NO	YES	24 S.F.	SEAL EDGES
39	10B	NO	YES	48 S.F.	SEAL EDGES
40	10B	NO	YES	48 S.F.	SEAL EDGES

SPRAYED-ON MATERIAL ABATEMENT OF SHAFT IS RECOMMENDED

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
5	11B	NO	YES	1 S.F.	SEAL EDGES
12	11B	NO	YES	1 S.F.	SEAL EDGES
19	11B	NO	YES	2 S.F.	SEAL EDGES
28	11B	NO	YES	2 S.F.	SEAL EDGES
31	11B	NO	YES	48 S.F.	SEAL EDGES
33	11B	NO	YES	2 S.F.	SEAL EDGES
40	11B	NO	YES	2 S.F.	SEAL EDGES

SPRAYED-ON MATERIAL

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
ALL	5B	YES	NO	NONE	NONE
ALL	48B*	NO	YES	***	ABATEMENT

48B SHAFT-SPRAYED-ON FIREPROOFING
*** 1'- FOOT STRIP ALONG LENGTH OF COLUMN MISSING

Note: Delamination is fireproofing whether sprayed or troweled no longer present on the steel members

WORLD TRADE CENTER
ELEVATOR SHAFTS ASBESTOS ASSESSMENT

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
3	14B	NO	YES	2 S.F.	SEAL EDGES
4	14B	NO	YES	2 S.F.	SEAL EDGES
8	14B	NO	YES	1 S.F.	SEAL EDGES
9	14B	NO	YES	1 S.F.	SEAL EDGES
10	14B	NO	YES	1 S.F.	SEAL EDGES
11	14B	NO	YES	1 S.F.	SEAL EDGES
12	14B	NO	YES	1 S.F.	SEAL EDGES
13	14B	NO	YES	1 S.F.	SEAL EDGES
14	14B	NO	YES	1 S.F.	SEAL EDGES
15	14B	NO	YES	1 S.F.	SEAL EDGES
16	14B	NO	YES	1 S.F.	SEAL EDGES
17	14B	NO	YES	1 S.F.	SEAL EDGES
18	14B	NO	YES	1 S.F.	SEAL EDGES
23	14B	NO	YES	1 S.F.	SEAL EDGES
24	14B	NO	YES	1 S.F.	SEAL EDGES
25	14B	NO	YES	1 S.F.	SEAL EDGES
26	14B	NO	YES	1 S.F.	SEAL EDGES
27	14B	NO	YES	1 S.F.	SEAL EDGES
28	14B	NO	YES	1 S.F.	SEAL EDGES

SPRAYED-ON MATERIAL

FLOOR	SHAFT	FIREPROOFING INTACT	DELAMINATION	QUANTITY DELAMINATED	RECOMMENDATION
310	15B	NO	YES	4 S.F.	SEAL EDGES
3	15B	NO	YES	2 S.F.	SEAL EDGES
4	15B	NO	YES	4 S.F.	SEAL EDGES
22	15B	NO	YES	1 S.F.	SEAL EDGES
25	15B	NO	YES	8 S.F.	SEAL EDGES

SPRAYED-ON MATERIAL

Note: Delamination is fireproofing whether sprayed or troweled no longer present on the steel members.

THE PORT AUTHORITY OF NY & NJ

TWO WORLD TRADE CENTER, 37TH FLOOR
NEW YORK, NY 10048

(212) 435-7000
(201) 961-6600

October 18, 2000

R. W. Crandlemere & Associates
549 Columbian Street
Suite 305
Weymounth, MA 02190

RE: **ASBESTOS DUE DILIGENCE: INFORMATION REQUEST.**

Dear Mr. Crandlemere:

Please find attached the responses to your October 12, 2000 fax wherein you requested that the available asbestos information be broken down into seven areas. In addition, responses to your general information requests are also provided.

Request: **Total remaining and total removed ACM, broken down by material types and locations, within the designated areas as mucb as practical (e.g. by floor number or other description; such as within pipe chase or the elevator shafts).**

The attached breakdowns for 1 WTC, 2 WTC, 4 WTC, 5 WTC, MERs, Subgrade, and Concourse disclose the estimated amounts of asbestos-containing sprayed-on fireproofing and thermal system insulation material present. Drawings identifying these asbestos locations by sample number are on file in my office. Attachments disclosing the amounts of vinyl asbestos floor tiles present as of April, 2000 are also included. These estimates were provided by the Port Authority's Engineering Department, Asbestos Litigation Task Force, and the World Trade Department.

Asbestos-containing roofing material was removed from the MER set-backs in 1 and 2 World Trade Center, and the roofs of 4 and 5 World Trade Center. The roofs of 1 and 2 World Trade Center were not sampled.

Request: The abatement costs for work performed and anticipated future abatement costs for each type of remaining known ACM.

From 1986 to 1999, a total thirty one (31) contracts were bid, and a total of $58.2 million dollars was spent in abatement projects. The Engineering Department estimates the cost for vinyl asbestos floor tile removal to be between $5 - $6 per square foot, sprayed-on removal to be between $20 - $25 per square foot, and thermal system insulation to be $15 per linear foot (outer diameter dependant).

As of September, 2000, a total of 2,184,038 million square feet of sprayed-on fireproofing, and 3,500,000 million square feet of vinyl asbestos floor tile was removed. According to PA records, a total of seven million square feet of vinyl asbestos floor tiles were installed in the World Trade Center.

Request: Materials determined not to be ACM (e.g. spline ceilings, hung ceilings, wallboard, wallboard joint compound, etc., as well as areas of sprayed-on fireproofing determined not to be ACM).

Sampling of the building materials noted above did not disclose the presence of asbestos.

Request: Any materials that are assumed to be ACM (such as fire doors) with an estimate, if possible, of the amounts of each material.

Our presumption as to the types of asbestos-containing building materials within the World Trade Center did not include fire doors. Based upon sample data, asbestos containing building materials appear to be limited to sprayed-on fireproofing, thermal system insulation, and floor tiles and mastic.

Request: Asbestos litigation status.

Your information request has been forwarded to the Port Authority's Law Department. We will notify you accordingly.

The following information is in response to your fax dated Wednesday, October 18th.

Request: PCB-containing Hydraulic Fluid.

The hydraulic fluid (hydraulic oil # 32 AW) leaking from elevator FE-5, located on the B4 Level of 1 World Trade Center does not contain PCB. I have a copy of the Material Safety Data Sheet from the distributor; Consumers Oil, 515 South First Avenue, Mt. Vernon, N.Y.. Hydraulic elevator FE - 6 in 2 World Trade Center also uses hydraulic oil # 32 AW.

Relating to the trash compactors, please note that the hydraulic fluid is ordered through the Port Authority Stockroom from an approved list of chemical products established by the Inspection & Safety Division. The hydraulic fluid used for the trash compactors is either mineral or vegetable based. Both are non-PCB products.

Request: Additional Information Regarding Radio-Frequency Testing.

I do not have a copy of, nor do I have knowledge of the March ,1999 report prepared by Denny & Associates recommending additional RF exposure monitoring. All radio-frequency documents are available for your review in the Document Room.

Please contact me at (212) 435-8507 should you have any questions or require additional information.

Phil Taylor
Phil Taylor
World Trade Operations &
Maintenance Management

Cc: J. Connors, A. Reiss, L. Zucchi

I V.

Excluding MERs, Truckdock, and Subgrade Locations

Location	Floors	Amount
Forty three floors with less than 160 sqft of sprayed-on fireproofing*:	1st – 40th floor Electric Closets, 36th Floor Perimeter Electric Closet, 82nd Floor 104th Floor	6,888 sqft

** Classified as "Random Locations On Floor" in WTC Disclosure Memorandum*

Six floors with less than 10 sqft of cementitious insulation behind convector units*:	77th, 79th, 88th, 101st, 103rd, and 105th Floors	60 sqft

** Classified as "Convector Units" in the WTC Disclosure Memorandum*

Full Floor Locations*:

Five core floors with 12,000sqft of sprayed-on fireproofing:	1st, 2nd, 3rd, 4th, and 5th Floors	60,000 sqft
6th Floor Plus Catwalk		43,000 sqft
Lobby Mezzanine		15,000 sqft

** Classified as "Full Floor Locations" in the WTC Disclosure Memorandum*

PA Café Kitchen Exhaust Duct	43rd 44th Floor	1,000 lnft
Thermal System Insulation On Vertical Steam Line:	B6 108th Floor	1,430 lnft

1, 2, 4, and 5 WTC

Mechanical Equipment Rooms

1 WTC:

7th / 8th Floor MER	25,000 sqft of sprayed-on / TSI present but quantity unknown
41st / 42nd Floor MER	25,000 sqft of sprayed-on / " " " " "
75th / 76th Floor MER	25,000 sqft of sprayed-on / " " " " "
108th / 109th Floor MER	25,000 sqft of sprayed-on / " " " " "
<u>TOTAL:</u>	<u>100,000 sqft of sprayed-on / TSI quantity unknown*</u>

* Non-fiberglass wrapped piping components, such as elbows, fittings, and flanges contain asbestos.

2 WTC:

41st / 42nd Floor MER	25,000 sqft of sprayed-on / TSI present but quantity unknown
<u>TOTAL:</u>	<u>25,000 sqft of sprayed-on / TSI quantity unknown*</u>

* Non-fiberglass wrapped piping components, such as elbows, fittings, and flanges contain asbestos.

4 WTC:

Non-ACM

5 WTC:

Non-ACM

1, 2, 4, and 5 WTC

SUBGRADES and TRUCKDOCK

Subgrades -

1 WTC:

B1 Level – Core, and N/E Quadrant	5,000 sqft / No TSI
B6 Level – Entire Level	40,000 sqft / No TSI
TOTAL:	45,000 sqft / No TSI

2, 4, and 5 WTC: No ACM

Truckdock -

Main Truckdock 50,000 sqft

1, 2, 4, and 5 WORLD TRADE CENTER

VINYL ASBESTOS FLOOR TILES

Amount Remaining in 1 WTC:	710,677 sqft
Amount Remaining in 2 WTC:	1,734,032 sqft
Amount Remaining in 4 WTC:	241,000 sqft
Amount Remaining in 5 WTC:	167,515 sqft

WTC 1
VAT ABATEMENT STATUS DIAGRAM

Zone	WTC FLOORS	TOTAL installation area	ABATED Sq Ft VAT IN CLAIM	JOBNUMBERS IN CLAIM	ABATED Sq Ft VAT NOT IN CLAIM	JOBNUMBERS NOT IN CLAIM	REMAINING Sq Ft VAT ON FLOOR	WTC FLOORS
	110							
	109 MER / 108 MER							
	107	35900	900.00	118,??8				110
	106	35900	35,?20.00	119				109 MER / 108 MER
	105	35900	2,422.00	115,??8 / 118,1??	122	[illegible]	0	107
	104	35900					13539	106
	103	35900	519.00	118,?65,1??			24835	105
	102	35900					31290	104
	101	35900	30,000.00	115,742 / 118,082			0	103
	100	35900	4,000.00	118,752			2020	102
	99	35900	25,900.00	118,214			10789	101
	98	35900					0	100
	97	35900	35,900.00	115,008			34200	99
	96	35900					0	98
	95	35900	35,900.00	118,202			33635	97
	94	38215					25241	96
	93	35900	38,215.00	2??			38215	95
	92	38215					0	94
	91	35900	38,215.00	211			0	93
	90	35900	18,480.00	115,960 / 118,1??			0	92
ZONE B	89	35900	25,900.00	743, 744, 817, 954		1??	15893	91
	88	22891	1,700.00	305	735	325	4814	90
	87	35900	18,391.00	118,072			31950	89
	86	35900	4,500.00	118,099	4500	81?	0	88
	85	35900			1000	751	30454	87
	84	35900	8,000.00	118,778 / 118,078,100			32320	86
	83	35900	13,000.00	94?			25491	85
	82	35900	6,000.00	118,548			23543	84
	81	35900					17899	83
	80	35900	35,900.00	118,214 / 118,063			30104	82
	79	35900			250	311	0	81
	78	35900	7,000.00	115,902 / 118,115			30188	80
	77	35650	30,000.00	202			22885	79
	76 MER / 75 MER		13,100.00	844, 848	350	335	0 / 3820	78 / 77
	74	0					0	76 MER
	73	0					0	75 MER
	72	0					0	74
	71	0			344	849	0	73
	70	0			2940	318, 337	0	72
	69	0					0	71
	68	0					0	70
	67	0			2100	687	0	69
	66	0					0	68
	65	0					0	67
	64	0					0	66
	63	0					0	65
	62	0			2000	530	0	64
	61	0					0	63
ZONE 4	60	0					0	62
	59	0			34578	749	0	61
	58	0					0	60
	57	0					0	59
	56	0					0	58
	55	0					0	57
	54	34578					0	56
	53	34578	3,500.00	118,046			0	55
	52	34578	3,131.00	118,053			27421	54
	51	34578			1000	757	13348	53
	50	34578	18,000.00	118,097 / 151	250	813	29864	52
	49	0					18170	51
	48	0					0	50
	47	0					0	49
	46	34578					0	48
	45	34578	18,600.00	118,250, 890, 897 / 118,081			0	47
	44	0	20,000.00	978			8067	46
	43	0			1800	323, 359	14477	45
	42 MER / 41 MER						20804 / 0	44 / 43
	40	0					0	42 MER
	39	32890					0	41 MER
	38	32890					0	40
	37	32875	18,000.00	223, 872			30483	39
	36	32890	32,875.00	231, 738			18134	38
	35	32890			32875	238	0	37
	34	32890			32875	225	0	36
	33	32890			32875	244	0	35
	32	32890	31,400.00	224, 898			0	[illegible]
	31	32890					0	[illegible]
	30	32890	31,838.00	269			3	[illegible]
	29	32890	31,838.00	271			0	[illegible]
	28	32890	31,838.00	248, 737			0	[illegible]
	27	32890	31,526.00	285			0	[illegible]
	26	32890	31,838.00	272			0	[illegible]
	25	32890	31,290.00	252			0	[illegible]
ZONE 1	24	32890	31,290.00	271			0	[illegible]
	23	32890	30,290.00	264	500	958	0	[illegible]
	22	32890	30,290.00	253	500	958	0	[illegible]
	21	32890	31,233.00	850, 870			0	[illegible]
	20	32890			32890	238	0	[illegible]
	19	32890	31,290.00	289			0	[illegible]
	18	32890	32,890.00	116			0	[illegible]
	17	32890	30,873.00	[illegible]			0	[illegible]
	16	32890	30,873.00	283, 849			0	[illegible]
	15	32890			30872	233	0	[illegible]
	14	32890	30,873.00	287			0	[illegible]
	13	32890	30,873.00	280			0	[illegible]
	12	32890	30,873.00	291		838	0	[illegible]
	11	32890	30,872.00	250			0	[illegible]
	10	32890			30872	221	0	[illegible]
	9	32890			30872	221	0	[illegible]
	8 MER / 7 MER				33672	240	0	[illegible]
	6	1798						8 MER / 7 MER
	5	2334			1700	314		
	4	2822					88	6
	3	2800					2834	5
	PLAZA	1054					2322	4
	CONCOURSE	11000					2800	3
	B1	8500	13,930.00	118,122			1058	PLAZA
	B2	13400	3,000.00	118,521			500	CONCOURSE
	B3	12000	13,400.00	118,048, 060, 133			9600	B1
	B4	12000	4,470.00	118,0?5, 088, 067			0	B2
	B5		3,500.00	118,163			2410	B3
	B6	2000	1,750.00	118,077			9003 / 0	B4 / B5 / B6
	TOTAL	[illegible]	[illegible]		[illegible]		[illegible]	

[illegible] per floor [illegible]

ATTACHMENT 8

Crandlemere and Associates Roof Mounted Transmission Devices
Document Review & Evaluation

R. W. CRANDLEMERE & ASSOCIATES, INC.
PROTECTING BUSINESS AND THE ENVIRONMENT

ROOF-MOUNTED TRANSMISSION DEVICES

DOCUMENT REVIEW AND EVALUATION

ONE WORLD TRADE CENTER

NEW YORK CITY, NY 10081

Project #000095

Merritt & Harris, Inc. #20-251E

User:

Merritt & Harris, Inc.
Attn: Mr. Robert G. Weiland, V. P.
110 East 42nd Street, 12th Floor
New York City, NY 10017-5685

Date Issued: November 7, 2000

549 Columbian Street, Suite 305, Weymouth, MA 02190 Tel. (781) 340-6161 Fax (781) 340-9191

The review and evaluation of documents provided regarding the roof mounted transmission devices described herein was conducted by the undersigned, of R. W. Crandlemere & Associates, Inc. (CRANDLEMERE & ASSOCIATES). CRANDLEMERE & ASSOCIATES assessment consisted solely of the activities described in the Introduction of this report The assessment was conducted in accordance with the Scope of Work described in our Proposal No. 00-090. It is subject to the Limitations and Service Constraints submitted in Appendix A of the ASTM Phase I Environmental Site Assessment provided as part of this Project. See Appendix F of that report for ASTM definitions of word in italics in this report.

Report Prepared by:

R. Wayne Cr

R. Wayne Crandlemere
President

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Background

R. W. Crandlemere & Associates, Inc. (CRANDLEMERE & ASSOCIATES) was retained by Merritt & Harris, Inc. (the *user*) to conduct an ASTM E1527-97 Phase I *Environmental Site Assessment* (ESA) of One, Two, Four and Five World Trade Center, located in the Borough of Manhattan, New York City, New York, 10081.

It is our understanding that Merritt & Harris, Inc. is providing this information in conjunction with, and as part of, a larger assessment of the *property* and has named The Port Authority of New York and New Jersey as an *additional user* as defined by the ASTM Standard E1527-97 Section 3.3.39. As an *additional user*, The Port Authority of New York and New Jersey may rely on the information presented in this report.

This report presents CRANDLEMERE & ASSOCIATES' professional opinion, and no warranty, expressed or implied, is made. The Port Authority of New York and New Jersey has the right to reproduce in full and provide copies of this report to interested parties. All reports, both verbal and written, are for the benefit of The Port Authority of New York and New Jersey and its' agents, employees, participates, and assigns.

On September 26, 27, 28 and 29 and October 10 and 11, 2000 Mr. R. Wayne Crandlemere of CRANDLEMERE & ASSOCIATES conducted a *Site visit* to identify *recognized environmental conditions* at the Site. In addition, CRANDLEMERE & ASSOCIATES' assessment included reconnaissance of adjacent properties, background research, and review of available local, state and federal regulatory records regarding the presence of petroleum products or hazardous materials at or in the vicinity of the Site.

The results of our work regarding the ASTM Standard for a Phase I Environmental Site Assessment of the Site is provided in a separate Phase I ESA report.

Discussions related to the facility programs that deal with asbestos-containing materials (ACM) and the electro-magnetic radiation related to the antenna tower on One World Trade Center are included in the condition assessment reports related to each building (One, Two, Four & Five World Trade Center), the Retail Mall and Plaza, Central Services and Sub-grade areas.

This report is a discussion of the information specific to the One World Trade Center, the North Tower related only to the roof-mounted transmission devices located on One World Trade Center, the North Tower, and their potential impact on workers and or visitors at One World Trade Center and visitors to Two World Trade Center, the South Tower. See the other specific reports for information specific to those buildings and facility areas.

1.2 Scope of Work

Beyond the Scope of Work of the ASTM Standard for a Phase I Environmental Site Assessment, but as requested by the *user*, reports related to safety issues regarding the roof-mounted antennas on the Site was performed by R. W. Crandlemere & Associates, Inc. Reports concerning the roof-mounted transmission devices were reviewed to determine the extent and nature of any additional studies or reports necessary to satisfy the due diligence requirements of a typical institutional acquisition entity related to safety concerns regarding the use of broadcast antennas on the roof of One World Trade Center, the North Tower.

2.0 REVIEW OF DOCUMENTS

There is a 360 foot tall antenna mast (Photo #1) rising from the top of the One World Trade Center Tower extending to a height of 1,728 feet above ground level. The tower and roof have antennas reported to service 9 television stations and 4 FM radio stations, and has an additional 83 wireless communication antennas (Photos #2, 3 & 4). As part of this assessment, CRANDLEMERE & ASSOCIATES reviewed the following documents provided by the owner:

- "An Evaluation of the Radiofrequency Environment at the World Trade Center North Tower", September 29, 1997, prepared by Richard Tell Associates, Inc., Las Vegas, NV;

- "Radiation Safety Survey of World Trade Department Ion Mobility Spectrometer Instrument – One World Trade Center" Memorandum March 11, 1998, prepared by Paul W. Mitchell, Environmental and Occupational Health Division, Risk Management, The Port Authority of New York & New Jersey;

- "Antenna Structure Registration", issued 3/23/98, Registration #1002506, U.S. of America, Federal Communications Commission:

- "RF Safety Awareness for World Trade Center Workers, A Presentation at the World Trade Center", dated February 1999 (2/3/99) presented by Richard Tell Associates, Inc. of Las Vegas, NV;

- "Engineering Report Electromagnetic Field Strength Survey at the South Tower of the World Trade Center", March 17, 1999, prepared by Denny & Associates, P.C., Washington, DC;

- "Radiation Safety Survey – One World Trade Center", Memorandum July 26, 1999, prepared by Paul W Mitchell, Environmental and Occupational Health Division, Risk Management, The Port Authority of New York & New Jersey;

- "A Reevaluation of Radiofrequency Fields on the World Trade Center North Tower", September 15, 2999, Revised March 21, 2000, prepared by Richard Tell Associates, Las Vegas, NV;

- "Radiation Safety Survey – One World Trade Center", January 27, 2000, prepared by Paul W. Mitchell, Environmental and Occupational Health Division, Risk Management, The Port Authority of New York & New Jersey;

- "An Investigation of RF Safety Considerations on the World Trade Center Antenna Mast Relevant to Work to Install a New Digital Television Antenna" May 12, 2000, prepared by Richard Tell Associates, Las Vegas, NV; and

- "Radiation Safety Survey – One World Trade Center", July 28, 2000, prepared by Paul W. Mitchell, Environmental and Occupational Health Division, Risk Management, The Port Authority of New York & New Jersey.

All above cited documents are attached.

The May 12, 2000 Richard Tell Associates (Tell) report indicates "controls are in place to restrict access to the rooftop to personnel who have been trained in radio frequency (RF) safety matters or who are escorted by someone who has been so trained." On the date of CRANDLEMERE & ASSOCIATES roof visit, the access to the roof was so restricted (Photo #5) and Mr. Crandlemere was so escorted. The Tell report states "special procedures are in place for tower maintenance activities to prevent exposure to RF fields that would exceed the occupational/controlled maximum permissible exposure) MPE limit." Tell's work, as described in their May 12, 2000 report, as well as in their previous work, included "RF field measurements... taken in... designated work region(s) and provides insights and recommendations that will assist in complying with the FCC rules." Appendix C of the May 12, 2000 report includes a Roof Map of RF Fields which indicates only 0.72% (195 square feet) of the roof area potentially exceed FCC RF MPE limits for occupational/ controlled exposures on the roof of the One World Trade Center, the North Tower. They further report "It is important to emphasize that these calculated results are based upon an assumption that all wireless telecommunications antennas on the roof are simultaneously active; that is likely not the case most of the time."

The Radiation Safety Survey reports all indicate acceptable test results. Our review of the documents provided indicate apparently reasonable RF surveys have been performed, safety surveys are performed and personnel safety protocols are in place. Mr. Taylor provided training materials from a presentation made to World Trade Center employees on February 3, 1999. This review did not include any additional field testing nor evaluation of their raw data. The Tell reports indicate that "Under normal broadcasting conditions, complying with the site guidelines of maintaining a minimum clearance of 3 feet from all antennas will likely suffice to control personnel exposures, most of the time." They further report, however, that during the "Tower maintenance mode of operation, access to the roof should be carefully controlled with due attention paid to roof field maps for guidance on areas of suspected maximum field levels. It is during the times of "maintenance mode" operation that field strengths are expected to be the highest and some areas of the roof may exceed the FCC MPE limits for occupational/controlled exposures by up to nearly 3 times the MPE limit.

Work performed by Denny & Associates as reported March 17, 1999, indicates that the RF levels measured on the outside observation deck of Two World Trade Center, the South Tower, exceed "the maximum permissible level for general population/ uncontrolled exposure... for certain modes of auxiliary broadcast antenna use at WTC1 (North Tower)." They conclude that "The basic finding of this survey is that only the low band VHF television stations can operate using their auxiliary antennas without causing overexposure of the outdoor observation deck walkway at WTC2." That report indicates "Further investigation of the WTC2 exposure levels is warranted." "Since the

initial objective of identifying procedures by which the broadcast stations at WTC1 can employ either their main or auxiliary antennas without exceeding the FCC MPE for general population/uncontrolled environments on the observation deck walkway at WTC2 has not been achieved…additional studies will permit broadcasters at WTC2 to move closer and ultimately fulfill their objectives of assuring compliance with the FCC rules."

3.0 MAJOR FINDINGS AND CONCLUSIONS

Based upon the information reviewed and summarized above, it appears that operational guidelines are currently in place to provide protection for trained workers and trained or escorted visitors to the roof of One World Trade Center, the North Tower, meeting the requirements of FCC MPE limits for occupational/controlled exposures. However, the 1999 Denny & Associates report indicates that under certain conditions the broadcasting at One World Trade Center, North Tower, creates RF exposures on the Two World Trade Center, South Tower, roof-top outdoor observation deck walkway that exceed the FCC MPE limits for general population/uncontrolled exposure. They recommended additional investigation. Based upon these reports, CRANDLEMERE & ASSOCIATES also recommends additional investigation of the RF exposure levels on the roof-top outdoor observation deck walkway on Two World Trade Center, the South Tower, with the intent of identifying procedures under which broadcasts at One World Trade Center, the North Tower, do not create RF exposures exceeding FCC Rules on the Two World Trade Center, South Tower, observation deck.

APPENDIX A

APPENDIX A-1

Memorandum July 26, 1999
Regarding Radiation Safety Survey, One WTC

THE PORT AUTHORITY OF NY & NJ **MEMORANDUM**

TO: George Tabeek, Project Manager
FROM: Paul W. Mitchell
DATE: July 26, 1999
SUBJECT: **RADIATION SAFETY SURVEY - ONE WORLD TRADE CENTER**

COPY TO: N. Chanfrau, D. Karpiloff, M. Plaskon, P. Taylor, G. Wojnar

On June 10, 1999, staff of Inspection and Safety Division's Occupational Health Unit conducted the semi-annual Radiation Safety Survey of the Barringer IONSCAN 400 Ion Mobility Spectrometer located in the lobby of 1 WTC. Possession and use of the instrument is in compliance with the conditions of the general license. The instrument's New York State Department of Labor registration number is X-14101.

The survey included an inspection of the storage area and of the instrument, and leak test sampling. The results of the survey are attached. Leak test sampling of the Nickel 63 sealed source unit for detection of removable radioactivity was performed. The sample was submitted to Monitoring Services for analysis and the result was found to be acceptable. A copy of the report is attached for your records.

The next radiation safety survey is scheduled for December, 1999.

If you have any questions or require further information regarding this survey, I can be reached at (201) 216-2173.

Paul W. Mitchell

Paul W. Mitchell, CIH
Manager
Occupational Health
Inspection and Safety Division

Attachments

WORLD TRADE DEPARTMENT
WORLD TRADE CENTER
RADIOACTIVE SOURCE SURVEY

INSTRUMENT	REMOVABLE RADIOACTIVITY TEST RESULT	INSTRUMENT IS SECURELY STORED	INSTRUMENT IS PROPERLY LABELED	OPERATOR'S MANUAL IS AVAILABLE
Barringer Instruments IONSCAN 400 Ion Mobility Spectrometer Serial No. 10A	Acceptable	Yes	Yes	Yes

Monitoring Services

P.O. BOX 580648 • HOUSTON TEXAS 77258-0648 • AREA CODE 713/641-0391 • FAX 713/641-6153

SEALED SOURCE LEAK TEST CERTIFICATE

PORT AUTHORITY OF NY & NJ
241 ERIE STREET ROOM 306
JERSY CITY ,NJ 07310
ATTN OF: WILLIAM POCKELS

C FILE 2194

S FILE 29636

N FILE 1662

INVOICE NO ______ DATE ______

RADIONUCLIDE NI-63

ACTIVITY 15 MCI CI SERIAL NO 10A

WIPE DATE 061099 WIPED BY ______

EFF .652

GROSS CPM 29 BKG CPM 19 NET CPM 10

$$\frac{\text{NET CPM}}{\text{EFF} \times 2.22 \times 10^{6}\ \text{DPM}/\mu\text{CI}} = \text{MICROCURIE}$$

THE ABOVE SOURCE WIPE TEST HAS BEEN ASSAYED IN ACCORDANCE WITH OUR RADIOACTIVE MATERIAL LICENSE AND THE APPROPRIATE REGULATORY REQUIREMENTS. THE REGULATIONS DEFINE A LEAKING SOURCE AS ONE FROM WHICH AN APPROPRIATE WIPE TEST HAS REMOVED 0.005 MICROCURIE OR MORE OF ACTIVITY.

THE REMOVABLE ACTIVITY WAS 6.91E-06 MICROCURIE

ASSAY NO. 070199 33 DATE 07-01-19 99

ASSAYED BY [signature]

APPENDIX A-2

"RF Safety Awareness for
World Trade Center Workers",
Presentation Folder

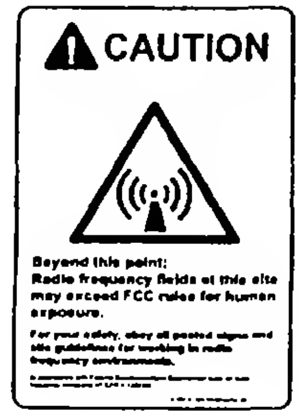
RF Safety Awareness for World Trade Center Workers

A Presentation at the

World Trade Center

New York, New York

February, 1999



Richard A. Tell

Richard Tell Associates, Inc.

8309 Garnet Canyon Lane

Las Vegas, Nevada 89129-4897

2/3/99

Internet: rtell@radhaz.com

www.radhaz.com

Voice: 702-645-3338

FAX: 702-645-8842

RF Safety Awareness for World Trade Center Workers

A Presentation at the

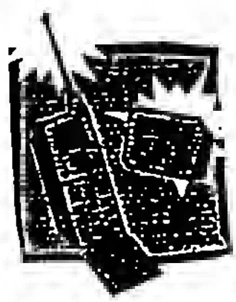
World Trade Center

New York, New York
February, 1999

Richard A. Tell
Richard Tell Associates, Inc.
8309 Garnet Canyon Lane
Las Vegas, Nevada 89129-4897

Voice: 702-645-3338 | Internet: rtell@radhaz.com www.radhaz.com | FAX: 702-645-8842

Just a Friendly Reminder



Keeping these items as quiet as reasonably possible during our meeting will be appreciated by all.

Richard Tell Associates, Inc. | Las Vegas, Nevada

Some Definitions

- RF for radiofrequency
- RFR for radiofrequency radiation
- EME for electromagnetic energy
- MPE for Maximum Permissible Exposure

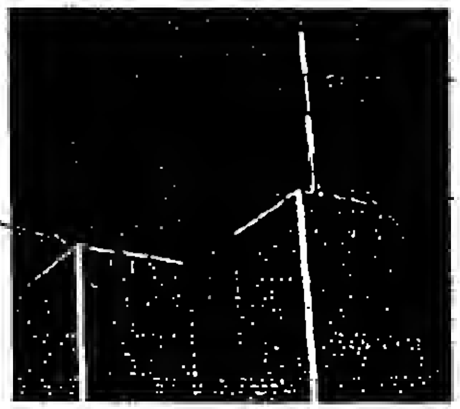
Richard Tell Associates, Inc. Las Vegas, Nevada

RF Safety Seminar Goals

- To learn what radiofrequency energy is;
- To learn about the biological effects of exposure to RF fields;
- To understand the RF exposure regulations that must be obeyed;
- To visualize the RF fields produced by antennas;
- To learn practical methods for preventing excessive RF exposure;
- To work with RF safety in mind.
- To learn about what the WTC has done for RF safety.

Richard Tell Associates, Inc. Las Vegas, Nevada

The World Trade Center Towers



Visitor viewpoint on south tower roof

Broadcast antenna mast on north tower

Wireless communications site on roof

The WTC broadcast facility provides service to the New York metropolitan area.

Richard Tell Associates, Inc. Las Vegas, Nevada

The WTC RF Environment

- The north tower of the WTC supports a a major radio and television broadcast facility;
- The north tower rooftop is also the location of many, lower powered communications antennas;
- RF safety precautions and procedures have been put into effect to ensure that work on the roof is safe;
- New Federal regulations make it important to understand the basic elements of RF safety.

Richard Tell Associates, Inc. Las Vegas, Nevada

Workers and RF Fields

- The installation and maintenance of broadcast and communications transmitting antennas requires that personnel may often work in close proximity to strong RF fields.
- Since strong RF fields can deliver significant energy to the body's tissues, care must be used to avoid excessive exposure that could be hazardous.
- New regulations from the Federal Communications Commission (FCC) require that all individuals working in certain RF environments become aware of RF safety related matters.

Richard Tell Associates, Inc. Las Vegas, Nevada

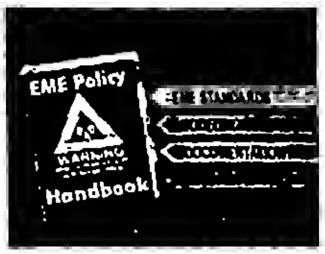
Why we are here.

This RF safety orientation seminar is designed to ensure that all relevant WTC workers receive appropriate information on this subject as required by new FCC rules.

Richard Tell Associates, Inc. Las Vegas, Nevada

What the WTC has done about RF safety

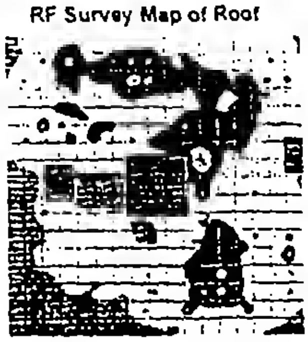
- The WTC, in concert with the broadcasters and telecommunications management firm, has developed a comprehensive RF safety program to meet these new FCC requirements for worker training.



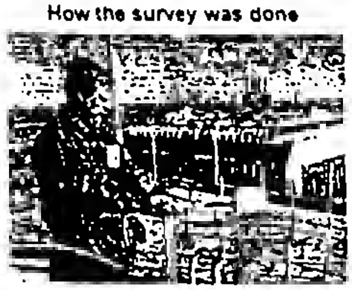
- This seminar addresses those issues deemed most important in the WTC RF safety program.

A Preview of what you will shortly see:

RF Survey Map of Roof

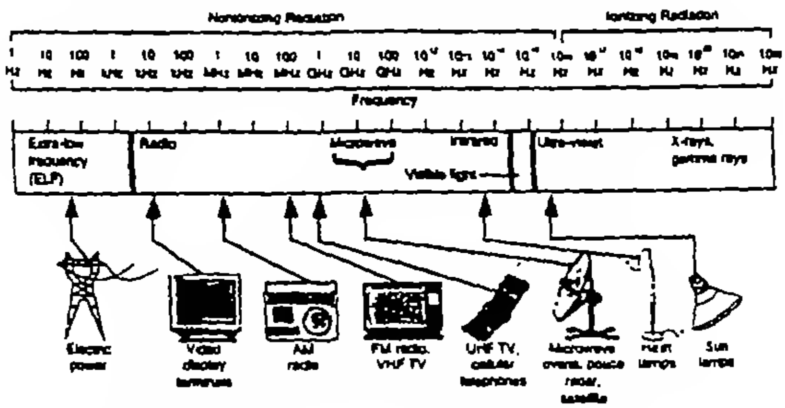


How the survey was done



Practical information based on real-world experience on how to stay safe when working on the roof of the WTC.

But, first, a word about the electromagnetic spectrum



Adapted from *Wireless Technical Services Phase II Project A Health and Safety Issues of Radio Frequency Fields from Wireless Communications Devices.* Electric Power Research Institute, 1996.

Richard Tell Associates, Inc. — Las Vegas, Nevada

Antennas are used to transmit many different types of signals including:

AM and FM radio broadcast signals;
Television signals;
Shortwave radio signals;
Two-way radio communications signals;
Cellular telephone signals;
Personal Communications Service (PCS) signals;
Paging signals;
Mobile radio service signals;
Satellite communications signals;
Air traffic control radar signals;
Microwave data communications signals.

Richard Tell Associates, Inc. — Las Vegas, Nevada

Wireless communications antennas can be found anywhere.

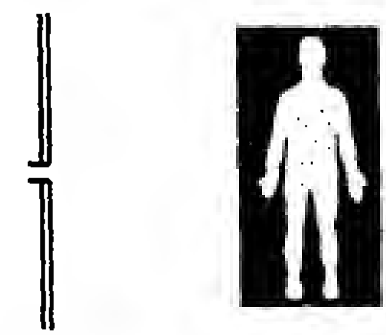
Richard Tell Associates, Inc. Las Vegas, Nevada

Important Parameters that Relate to RF Exposure

- Power density of RF field milliwatts per square centimeter (mW/cm^2)
- Frequency of RF field (MHz);
- Antenna input power (watts);
- Antenna size;
- Body position relative to antenna

Richard Tell Associates, Inc. Las Vegas, Nevada

The Body is Like a Fat, Absorptive Antenna



Richard Tell Associates, Inc. Las Vegas, Nevada

SAR

- SAR, or specific absorption rate, is the rate at which RF energy is absorbed by the body.
- It is measured in watts per kilogram of body tissue.

Richard Tell Associates, Inc. Las Vegas, Nevada

FCC RF Exposure Limits are Based on Specific Absorption Rate (SAR)*

For occupational/controlled exposures:

- Whole body average SAR = 0.4 W/kg
- Spatial peak SAR limit = 8 W/kg, except for
- Spatial peak SAR in extremities = 20 W/kg

*SAR is the rate at which RF energy is absorbed in the tissues of the body for a given incident power density.

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SAR is related to the energy absorbed by our body and

⇩

Power density is the intensity of the RF field to which we are exposed.

⇩

SAR helps us understand the relationship between the external RF field intensity and energy that gets absorbed.

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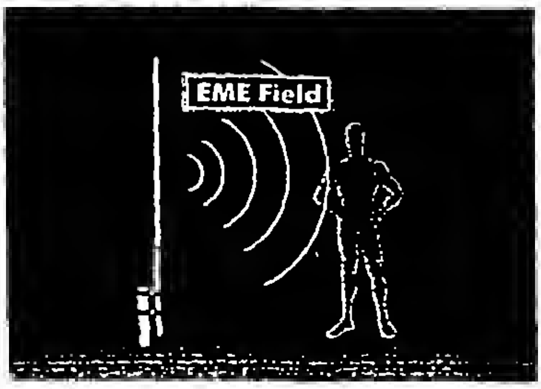
Very High Levels of Absorbed Energy Can Lead to Tissue Heating



But this will occur only when RF exposure substantially exceeds the FCC safe exposure limits

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Basis for the Exposure Limits Adopted by the FCC

- Observation of performance degradation in laboratory animals trained to perform a learned task when subjected to RF fields at high intensities sufficient to deliver an absorbed power of 4 watts per kilogram of body weight;
- Assumption that same effects might be possible in humans;
- Assumption that prolonged exposure could lead to a serious and adverse effect;
- Application of a safety factor of 10 to derive actual exposure limits.

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Let's get a practical 'feel' for SAR

If a typical coffee mug (350 ml) full of water heats 43°F (23.9 °C) in 1 min (real data from my kitchen), then the SAR in the water is about 1,668 W/kg! (A really thermalizing effect!)

REMEMBER, this is inside a microwave oven, not at an antenna site!!

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Now, let's get a 'feel' for 4 W/kg, the hazard basis of the FCC rules

For the coffee mug, an energy absorption rate of 4 W/kg would correspond to a temperature increase of about 0.057°C (or 0.10°F) in 1 minute.

If our body absorbed at the rate of 4 W/kg for an hour, and there was no loss of heat from the body, then we would expect an average body temperature increase of about 3.4°C or 6.2°F.

In reality, at least in neutral environments, blood flow will help reduce body temperature and the temperature increase will not be this much.

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Maximum Permissible Exposure (MPE)

- Maximum Permissible Exposure is the upper limit of RF field intensity, or power density, that is safe. It is at least 10 times lower than the actual hazard threshold.
- These limits depend on the frequency of the transmitted signals.
- The FCC has defined MPEs for all broadcasting and telecommunications stations.
- These limits have become a part of the FCC's regulations.

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Remember:

$$\text{MPE} = \frac{\text{Hazard level of exposure}}{10}$$

For persons provided with RF safety awareness training.

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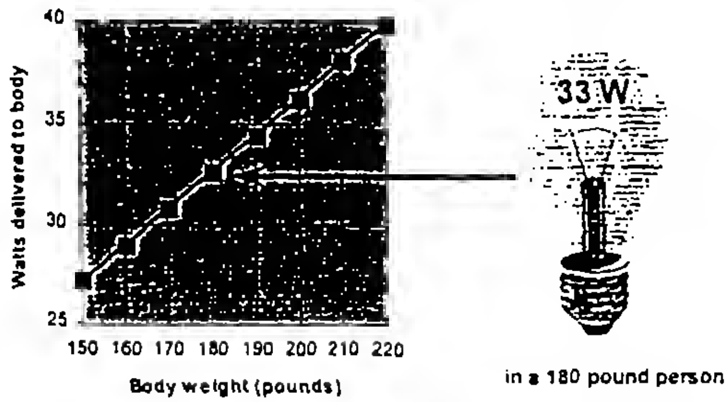
How much power might we absorb at the MPE limit of 0.4 W/kg?



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Some Important Observations from Biological and Medical Research of RF Fields

- RF fields are NOT the same as ionizing radiation. They cannot ionize tissue!
- RF fields are NOT believed to result in cancer.
- Biological effects are NOT accumulative like with ionizing radiation.
- Heating effects of RF exposure are related to a threshold below which no effects occur!

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So-called Non-thermal Effects

- Some research has indicated the possibility of so-called 'non-thermal' effects.
- These reported effects are subject to considerable debate in the scientific community as to whether they are real.
- General consensus is that if such effects actually exist, they are also protected against by present exposure limits.

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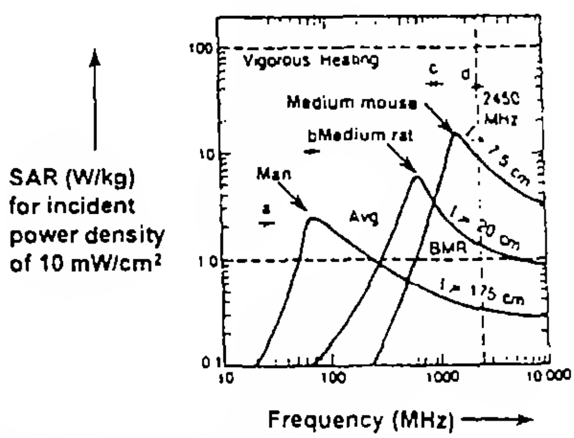
The Body Antenna Exhibits a Resonance Frequency Like a Real Antenna Related to Its Dimensions



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Who Develops the Limits?

- IEEE/ANSI - Institute of Electrical and Electronics Engineers and the American National Standards Institute
- NCRP - National Council on Radiation Protection and Measurements
- ACGIH - American Conference of Governmental Industrial Hygienists
- Numerous foreign governments and organizations

We don't measure SAR in the field!

- It just isn't socially acceptable!
- But, we can measure the intensity of the field, usually expressed as power density using special meters.
- The exposure limits depend on frequency since our bodies absorb RF energy similar to an antenna.

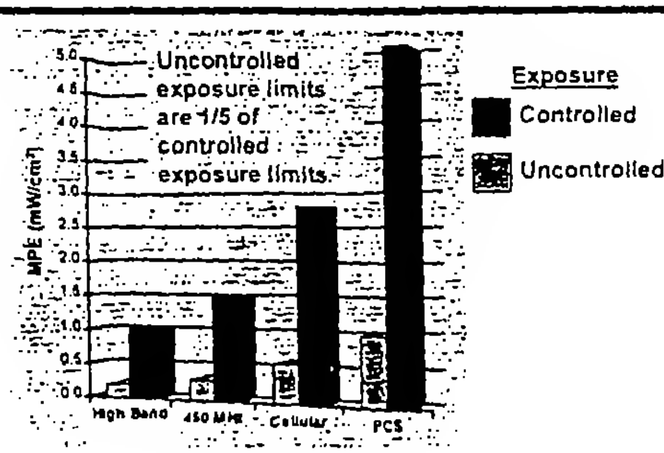
New FCC RF Exposure Standard Effective October 15, 1997

- Based on recommendations of National Council on Radiation Protection and Measurements
- Similar to IEEE/ANSI standard in <u>most</u> of telecommunications bands

Frequency (MHz)	Power density limit (mW/cm^2) Occupational/Controlled environment
30-300	1.0
300-1,500	f/300
>1,500	5.0

FCC Specified Limits for RF Exposure

Based on recommendations of the NCRP



The New FCC Rules:

- Were based on the NCRP recommendations and IEEE standard;
- Were adopted in 1996;
- Went into effect October 15, 1997;
- Supported by the Food and Drug Administration, the Environmental Protection Agency and the Occupational Safety and Health Administration

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OSHA

- OSHA expects all employers to be in compliance with the RF rules adopted by the FCC!
- All employers are expected to provide a safe working environment for their employees.
- OSHA has publicly expressed the policy of applying the FCC adopted rules.

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Important Observation about RF Exposure Standards

Almost all RF exposure standards are based on the same underlying scientific finding of a threshold for adverse biological effects at an SAR of about 4 watts per kilogram in the body.

The exposure limits we follow are set well below this threshold for adverse effects, at least 10 times lower.

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RF Burns Can Occur When Touching Bare Antenna Elements

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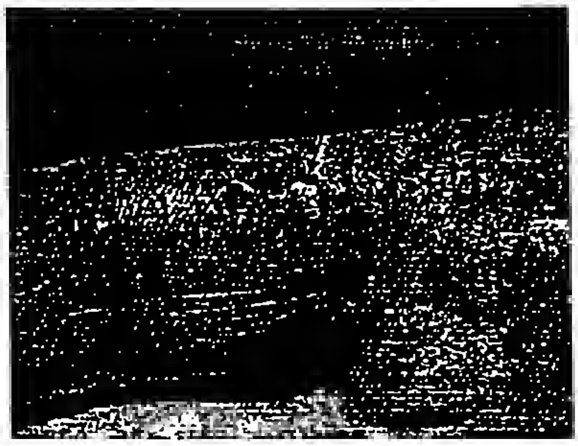
RF Burns May Occur When Touching Active Antennas



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Electromagnetic Compatibility A Precautionary Note!

- Certain implanted medical devices, such as cardiac pacemakers and defibrillators, may be interfered with by strong RF fields.
- Interference is generally unlikely with pacemakers but some newer, non-pacemaker devices may be susceptible.
- Employees with implanted medical devices should consult with their physician about any special preventive measures they can take to avoid adverse interference.
- Employees are encouraged to identify themselves to the company RF safety officer to discuss safety measures for specific antenna sites.

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RF Fields and Signals

The RF field near an antenna is the signal transmitted (radiated, emitted) by the antenna for purposes of communications or broadcasting.

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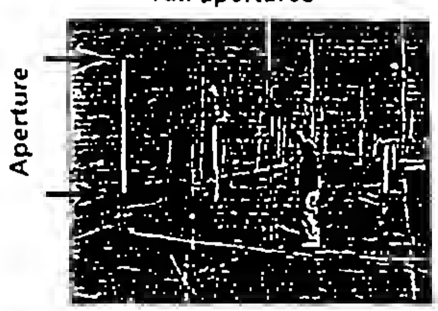
Antennas Come in All Sizes

Tall apertures



WTC roof-top base station antennas

Short aperture

Hand-held portable radios

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Antennas Transmit Radio Frequency Energy

Most antennas, however, emit RF energy in a directional pattern.

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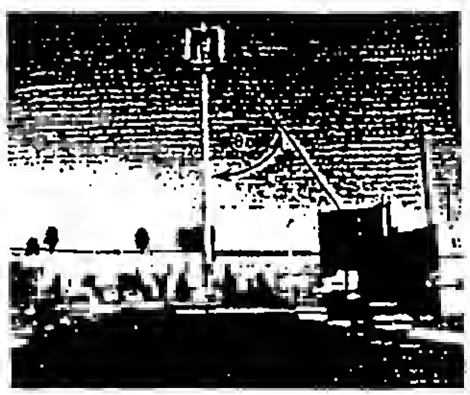
In the Far-field of a Cell Site

We can use the far-field radiation pattern of the antenna for calculations



And the resulting RF fields are miniscule.

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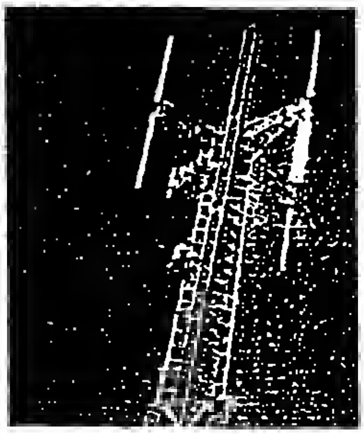
Work on a Cell Site Tower is Typically Done in the Near Field

A rural cell site in Puerto Rico



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An Example of High Power Pagers and Roof Access

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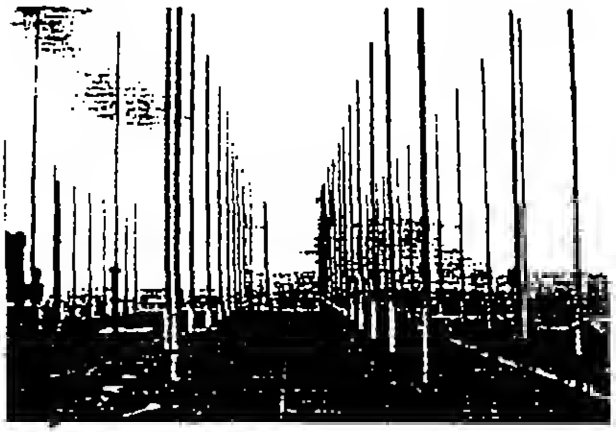
A High Density Communications Site



Sometimes it can be difficult to get far enough away from every antenna!

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Power density is related to:

- Power delivered to the antenna;
- Antenna directivity;
- Antenna size;

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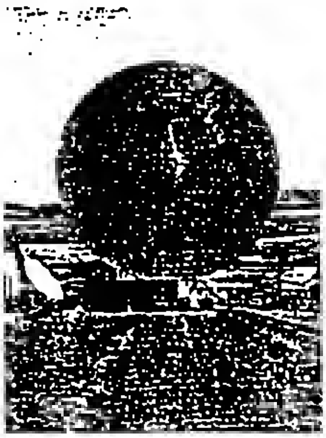
Some Interesting Observations



- ✓ Smaller antennas produce stronger fields near them than larger antennas with the same input power.
- ✓ The smaller the physical size of an antenna, the more concentrated the power density is near it since there is less aperture area over which the power is distributed.

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Roof Mounted Microwave Dish Antennas

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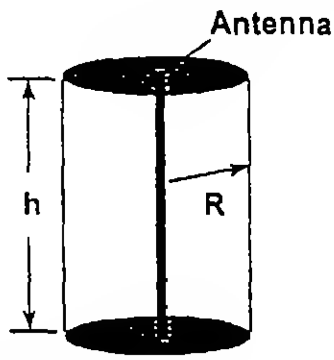
Very Simple Models can be Used to Predict RF Fields in the Near-field

This is an example for vertical, collinear (whip type) antennas.



$$S = \frac{P}{2\pi R h}$$

Distribute radiated power over surface area of an imaginary cylinder.

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MPEs are Based on Spatially Averaged Values of RF Fields

While local fields can be intense, compliance is generally determined by the spatially averaged RF field level.

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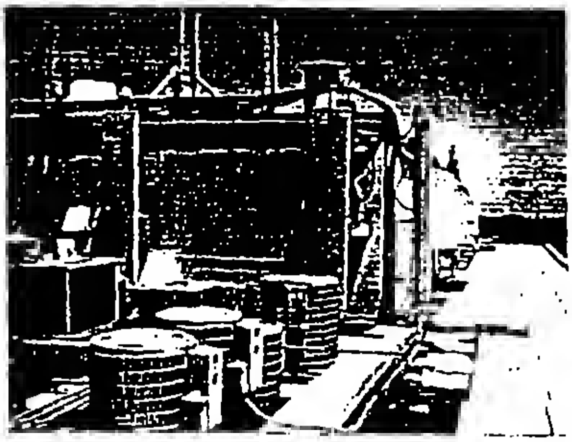
Antennas in Close Proximity to Air Conditioning Equipment Could Lead to Unnecessary Exposure



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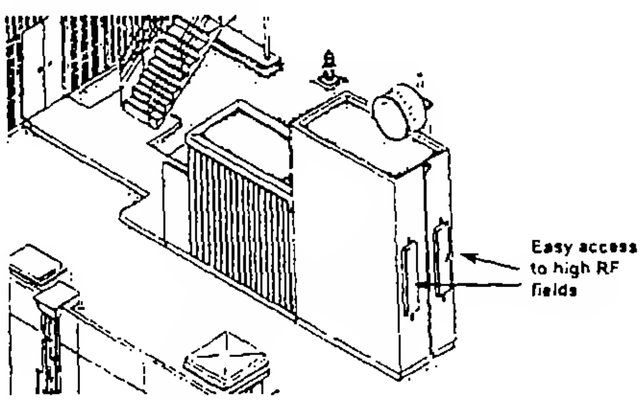
Convenient Antenna Mounting is Generally Incompatible with Controlling EME Exposure



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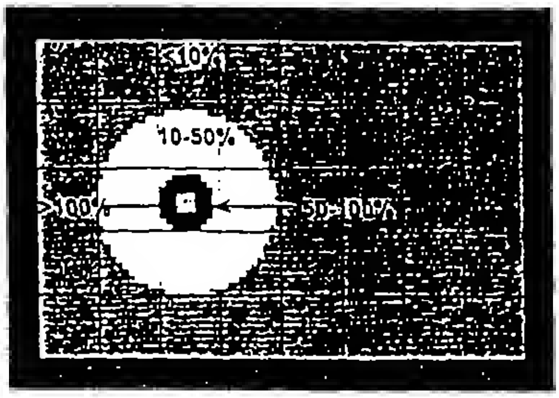
RF Fields Caused by Multiple Antennas are Additive



Produced with RoofView™ Software

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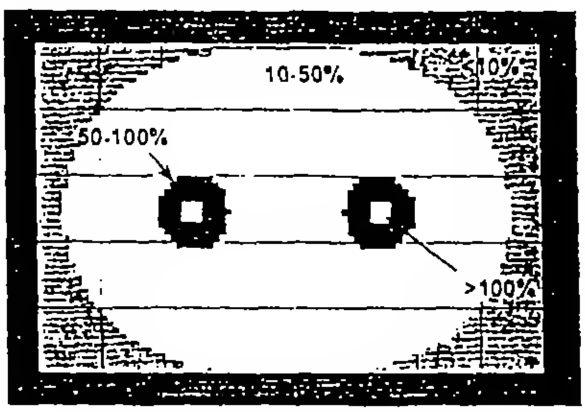
RF Fields in the Vicinity of Two Active Antennas



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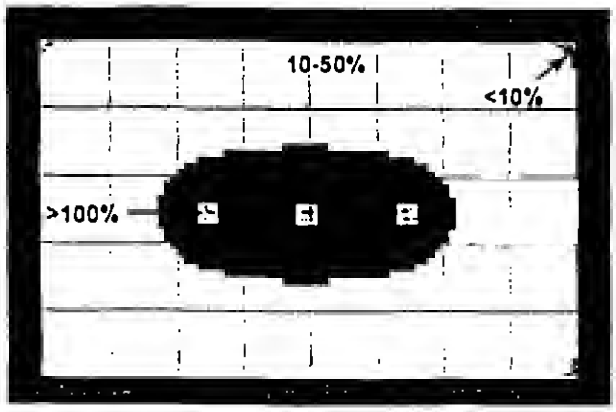
RF Fields in the Vicinity of Three Active Antennas



Produced with RoofView™ Software

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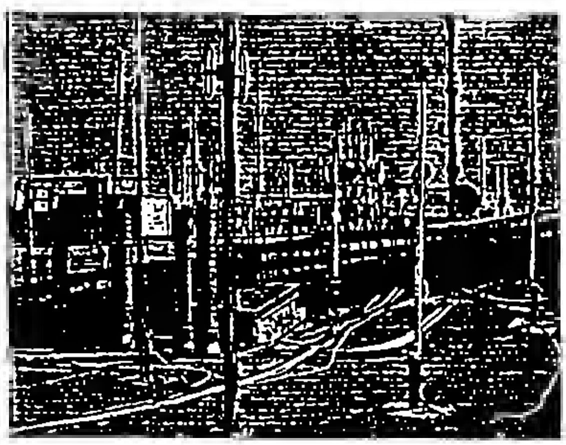
Antenna mounting density at the WTC can make it difficult to get away from strong fields



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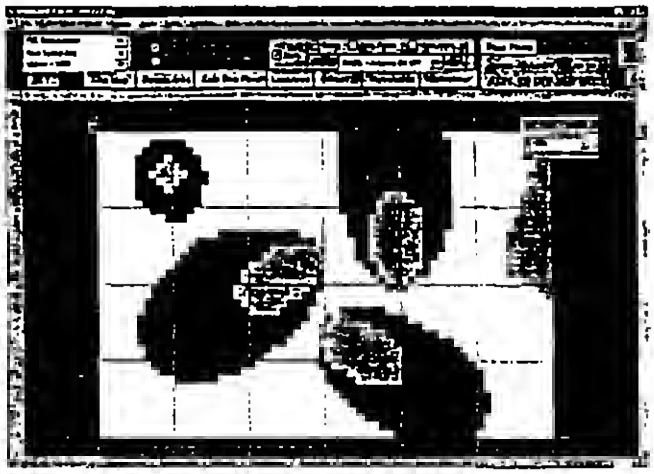
Sophisticated Software Analysis Programs can Also be Used to Assess RF Fields



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Preventing Excessive RF Exposure

The Practical Aspects of Staying Safe When Working Around Antennas

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The FCC Rules

- Are related to EXPOSURE of people

NOT

EMISSIONS!

- This is significant since it means that high RF fields at a site that are above the limits do not necessarily mean that the site is out of compliance.
- What counts is the RF field level to which individuals can actually be exposed.

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Being Aware of RF Safety

- FCC uses awareness to determine appropriate MPE limits to apply;
- EME awareness training;
- This training session is one way of becoming more aware of RF safety.

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Engineering Controls

- EME design is best way to avoid potentially excessive exposure;
- Raising antennas, for example, is an effective way to reduce fields on a roof-top site;
- Locate directive antennas away from accessible areas, roof tops and towers

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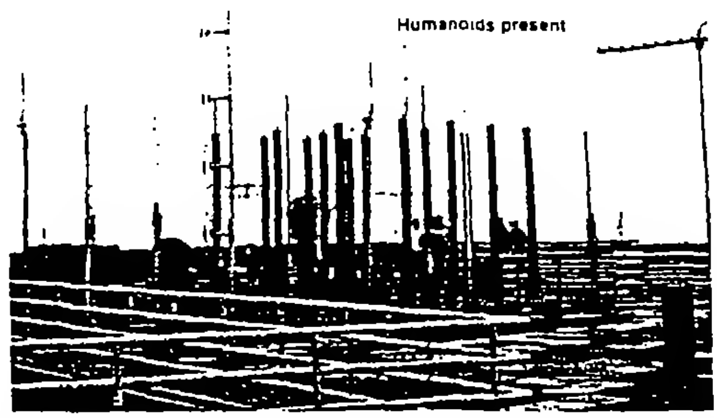
Entering a Paging Forest



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Identifying Areas of High Fields

- Simple calculations;
- Sophisticated computer analysis;
- RF field surveys;
- All of these have been accomplished for the WTC north tower roof.

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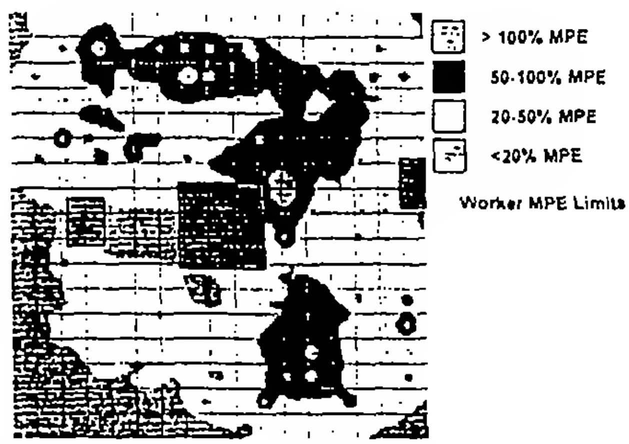
RF Survey Map of WTC North Tower Rooftop



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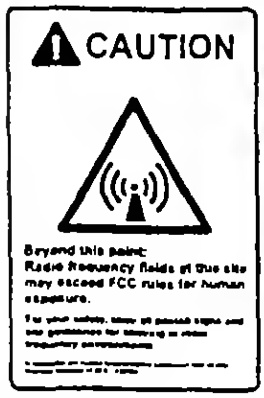
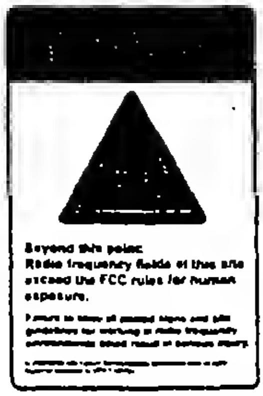
Alternative RF Alerting Signs





Sign designs available through
Richard Tell Associates, Inc.

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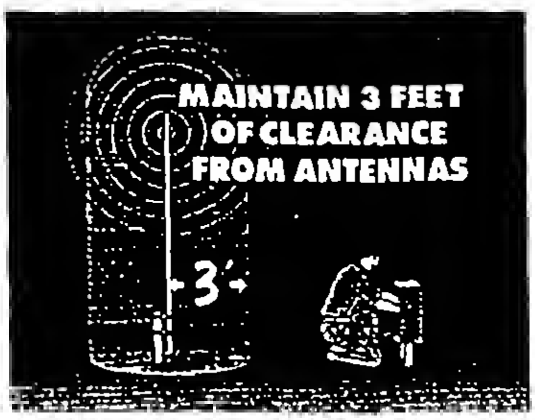
A Practical Rule of Thumb Applicable at Many Wireless Antenna Sites



Note: Some antennas may produce fields that exceed the FCC MPE at greater than 3 feet!

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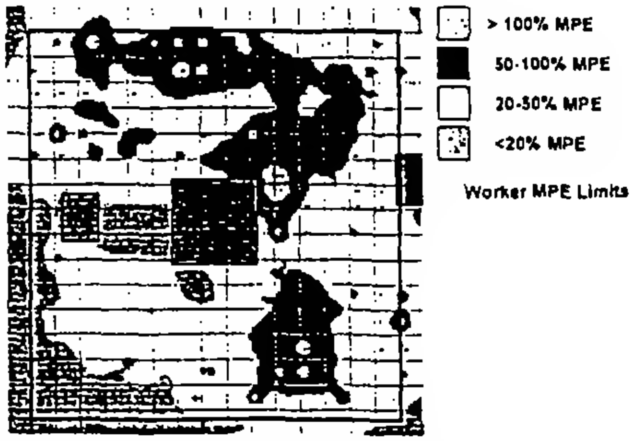
An Obvious Practical Insight from the Roof RF Survey Results

RF field levels around the edge are the weakest.



Using a walking path around the perimeter of the roof to avoid strong RF fields.

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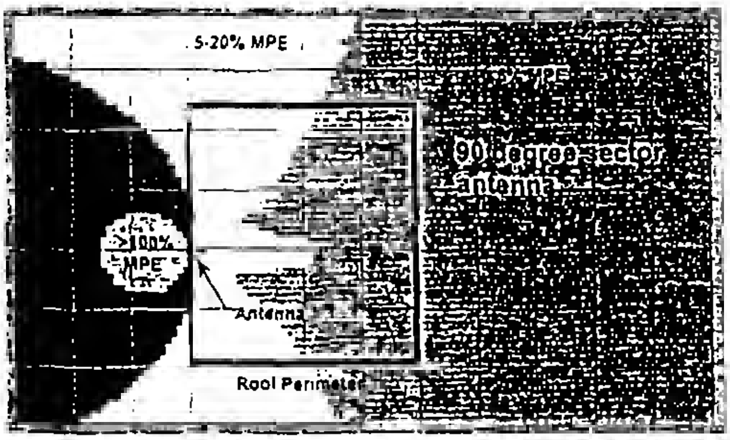
RF Fields Behind Directional Antennas are Usually Very Weak



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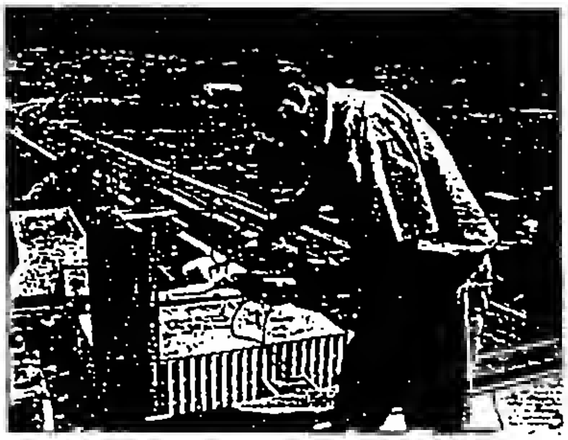
Back Lobe Fields, Even with Low Antenna Mounting are Generally Not a Problem



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Personal Monitors Can Provide Positive Feedback on Antenna RF Status

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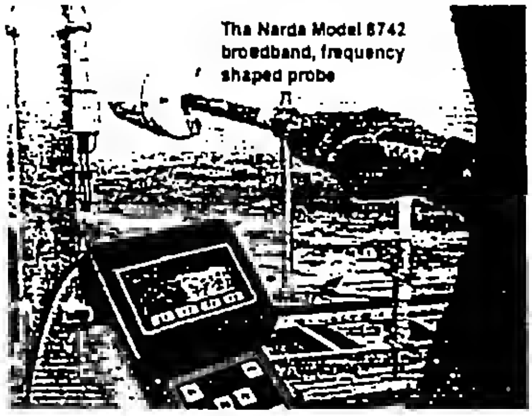
Using a Broadband, Isotropic Field Probe to Measure RF Fields at an Antenna Site



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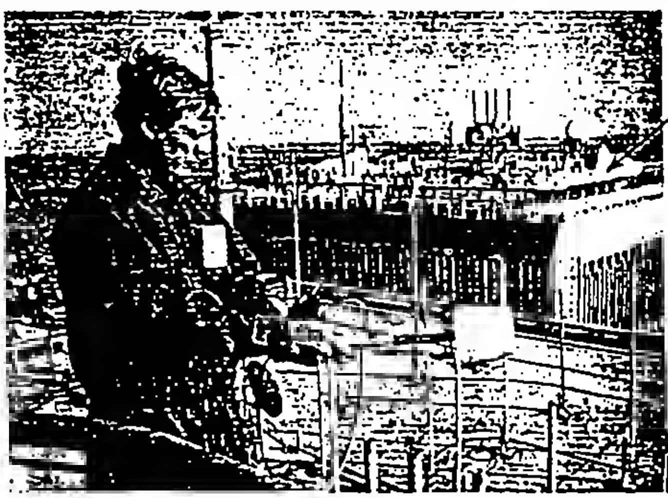
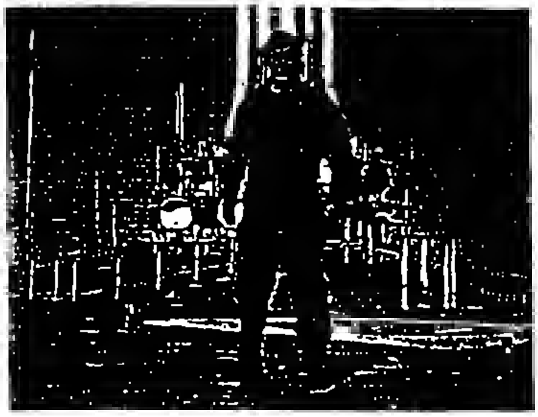
On Top of the WTC North Tower



New Fabrics Containing Microscopic Stainless Steel Fibers Can Substantially Reduce RF Exposure



The Naptex™ RF protective suit from NSP, Germany

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Worker Wearing an RF Protective Suit During Tower Work

Hood assembly necessary when 800 MHz or higher fields exceed 300% of MPE

The KW-GARD™ RF protective suit from Euclid Garment Manufacturing Co., Kent, Ohio

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General Elements of the WTC RF Safety Program

- Providing employee EME awareness;
- Using RF safety signs to help identify areas of excessive RF fields;
- Use of personal monitors;
- Use of protective clothing where applicable;
- Emphasizing work practices, as appropriate, for eliminating excessive RF exposure;
- Encouraging input from employees to arrive at most practical and effective ways of performing certain jobs with minimum potential RF exposure.

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Two Important Components of the WTC Program

WTC RF Safety Committee
This committee provides overall guidance relative to RF safety at the WTC.

WTC RF Safety Officer
This individual is your point of contact for any questions regarding RF safety during your work.

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Your Part in Making the WTC RF Safety Program Effective

- Review, know and follow guidelines;
- Use safe working practices defined by the program and your employer- This is no different than any other requirement for working safety such as using caution when working around high voltage equipment or machinery.
- Consult with the WTC RF Safety Officer- This individual is your point of contact for any questions regarding RF safety during your work.

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Site Guidelines Placard You Will See on the 1 WTC Roof Wireless Communications Site

⚠ NOTICE ⚠

GUIDELINES FOR WORKING IN RADIOFREQUENCY ENVIRONMENTS

- ⚠ All personnel should have electromagnetic energy (EME) awareness training.
- ⚠ All personnel entering this site must be authorized.
- ⚠ Obey all posted signs.
- ⚠ Assume all antennas are active.
- ⚠ Before working on antennas, notify owners and disable appropriate transmitters.
- ⚠ Maintain minimum 3 feet clearance from all antennas.
- ⚠ Do not stop in front of antennas.
- ⚠ Use personal RF monitors while working near antennas.
- ⚠ Never operate transmitters without shields during normal operation.
- ⚠ Do not operate base station antennas in equipment room.

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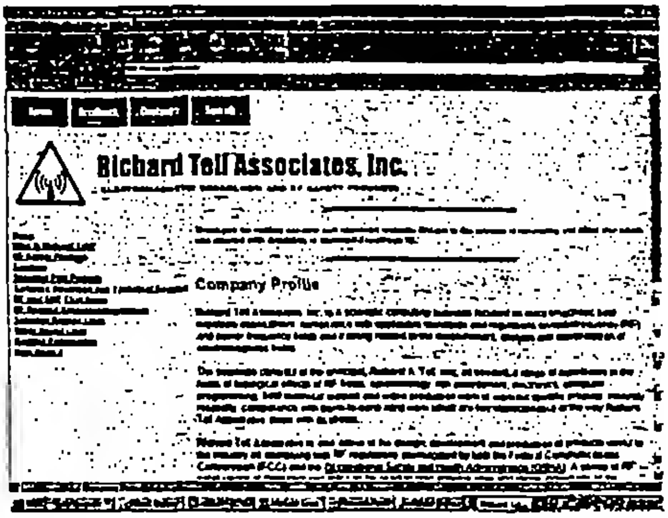
Web Sites Can Provide Useful RF Compliance Information



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APPENDIX A-3

Denny & Associates, P.C., Engineering Report

Denny & Associates, P.C.
Consulting Engineers
Washington, D.C.

ENGINEERING REPORT
ELECTROMAGNETIC FIELD STRENGTH SURVEY
AT THE SOUTH TOWER OF THE
WORLD TRADE CENTER

EXECUTIVE SUMMARY

Radio-frequency radiation surveys were conducted in December 1998 and January 1999 on the outdoor observation deck walkway of WTC2 (south tower). Previous surveys identified an area on the outdoor observation deck walkway at WTC2 where the maximum permissible level for general population/uncontrolled exposure is exceeded for certain modes of auxiliary broadcast antenna use at WTC1 (north tower). The previous exposure data were obtained with more than one broadcast station on the air, so it was not possible to analyze the aggregate exposure data to determine each broadcast station's individual contribution to the overall exposure level present in the area of concern.

The December measurements were made to identify those television stations able to use their auxiliary antennas at WTC1 without causing overexposure on the outdoor observation deck at WTC2. The basic finding of this survey is that only the low band VHF television stations can

operate using their auxiliary antennas without causing overexposure of the outdoor observation deck walkway at WTC2.

The January measurements were made with one station on the air at a time and individual station exposure data were obtained for each station using its main antenna. For those stations with an auxiliary antenna at WTC1, individual station exposure data also were obtained for that station with its auxiliary antenna in use. The January survey was designed to provide individual exposure data for each station and each mode of station operation. Based on all available information, contributions to the overall RF exposure environment at WTC2 from nonbroadcast sources in the area were expected to be small enough to be ignored and any bias statistically eliminated. However, in the final analysis, contributions from other nonbroadcast sources in the area proved to be too great to be ignored, and the individual broadcast station exposure data was biased by the contribution from nearby nonbroadcast sources. Because of the contributions from nonbroadcast sources, analysis of the January exposure data could not produce the desired result of determining the individual broadcast station contributions to the overall exposure present on WTC2.

Unfortunately, additional surveys will be required to accurately determine the individual broadcast station contributions to the overall exposure present on the outdoor observation deck walkway at WTC2. The next survey to be undertaken should duplicate the December 1998 measurements using new, more accurate instrumentation developed especially for characterizing general population/uncontrolled exposures. Measurements of this type can easily be made with minimal disruption, and the increased accuracy of the instrumentation may allow a conclusion of a slightly less than maximum exposure at WTC2 rather than the present conclusion of a slight overexposure.

If the new instrumentation continues to indicate a slight overexposure on the north side of the outdoor observation deck walkway at WTC2, then the next step will be to define and undertake a survey using instrumentation that will allow the WTC2 exposure to be characterized completely, fully identifying all contributors to the RF energy incident upon the walkway as individual broadcast station, cellular, PCS, paging, community repeater, and so forth. As no off-the-shelf instrumentation is available for this specialized purpose, a measurement system needs to be assembled and tested before this series of measurements can be made.

INTRODUCTION

The electromagnetic field strength surveys described in this report were undertaken on behalf of the television (TV) stations and FM radio stations operating at the World Trade Center as the second report to address exposure levels on the observation deck of the south tower of the World Trade Center (WTC2) from broadcast operations primarily located on the north tower of the World Trade Center (WTC1).[1] A low power television (LPTV) station is located on WTC2, but, as has been previously examined, the LPTV station contributes little to the radiofrequency radiation (RFR) exposure environment at WTC2. The FM and TV stations operating at WTC1 are identified in Figure 1 of this report.

---

1 The geographic coordinates for the WTC1 site are 40° 42′ 43″ North Latitude, 74° 00′ 49″ West Longitude referenced to the 1927 North American Datum (NAD 27).

BACKGROUND

There are two modes of operation for the broadcast stations located at WTC1: the normal mode and the auxiliary mode. In the normal mode of operation at WTC1, the TV and FM stations operate with their main antennas. In the auxiliary mode of operation, the FM stations operate with their main antennas, all of the VHF TV stations except WCBS-TV operate with their auxiliary antennas, and the UHF TV stations are off the air. WCBS-TV is the only VHF TV station that does not have an auxiliary antenna at WTC1. The WCBS-TV auxiliary antenna is located at the Empire State Building, 4.7 kilometers along a bearing of 30 degrees True from WTC1, and, accordingly, the WCBS-TV transmitter at WTC1 is shut down during auxiliary operation.

The need for additional exposure surveys at the World Trade Center was identified in January 1998 during the preparation of the license renewal applications for the FM stations located at WTC1. The FM licensees reviewed the RFR exposure issues related to their operations in light of the new Federal Communications Commission (FCC) Rules establishing new maximum permissible exposure (MPE) levels for human exposure to RFR

that were adopted in 1996 and implemented on October 15, 1997. Two major areas of concern were identified as a result of that review. One area of concern relates to the exposure levels of the roof of WTC1 and is the subject of a separate report.

The other area of concern is related to the exposure of visitors to the indoor observation area and the outdoor observation deck walkway at WTC2. This concern was partially addressed in the June 18, 1998, Denny & Associates, P.C. report which indicated that measured exposure levels within the indoor observation area and the outdoor observation deck walkway were found to be within the FCC MPE levels for general population/uncontrolled exposure for the normal mode of broadcast station operation, but measurements in an area of the outdoor observation deck walkway exceeded the FCC MPE Level for general population/uncontrolled exposure when the broadcast stations were operating in the auxiliary mode. The measurements made in support of this report were aimed at identifying the individual contributions of broadcast stations to the overall exposure levels on the observation deck walkway in order to mitigate exposure on the walkway during the auxiliary mode of operation.

SUMMARY OF FINDINGS

Two additional measurement programs were undertaken to develop procedures for reducing the exposure levels on the observation deck walkway during the auxiliary mode of operation. The first series of measurements made on December 17 and 18, 1998, measured exposure levels with different groups of television stations operating into their auxiliary antennas, while the remaining stations continued to employ their main antennas. The data from these measurements, which are tabulated in Figure 2 of this report, indicate that the exposure on a small portion of the north observation deck walkway, identified as point 2A in Figure 5 of this report, exceeds the FCC MPE for general population/uncontrolled exposure when some of the high-band VHF stations, including WABC-TV, WWOR-TV and WNET, employ their auxiliary antennas.

The December 1998 measurements were made using a conformal electric field probe that yields exposure level data as a percentage of exposure. The exposure levels measured using the occupational/controlled exposure electric field probe were multiplied by a factor of five to re-reference

the measured exposure levels to the MPE for general population/uncontrolled exposure.

Due to the limited sensitivity of the occupational/controlled exposure conformal electric field probe and the desire for greater resolution in the exposure data, a second measurement program was undertaken. The objective of the second course of measurements was to determine individually the exposure from each television station and, as a whole, the FM stations for both the normal and auxiliary modes of operation. To achieve this, all of the broadcast stations that operate from WTC1 and WTC2 went off the air on the morning of January 5, 1999. Exposure measurements were then made on the northern portion of the observation deck walkway with only one broadcast station at a time in operation. Numerous other paging, mobile radio and microwave facilities, over which the surveyors had no control, continued to operate from WTC1 and WTC2 while the individual broadcast station measurements were being made.

The recorded measurement data, tabulated in Figure 3 of this report, suggests higher than predicted exposure levels for most of the broadcast stations. When compared to the data collected in December 1998,

the summation of the individual station exposure levels measured in January 1999 yields total exposures far in excess of the December 1998 values. One possible explanation is the presence of high background exposure levels from nonbroadcast sources that could not be shut down during the survey. An exposure measurement was made at measurement locations 1, 1A, 1B, 2, 2A, 2B, and 3 as shown in Figure 5 with all of the broadcast stations off the air. The measured background exposure ranges from 13 to 30 percent of the MPE for general population/uncontrolled exposure over the seven points measured on the walkway. Further, complicating the presence of a high background exposure levels was the continuously varying level of the background exposure. Subtracting the measured background exposure at each point from the each station's measured level sometimes yields exposure levels less than zero. This is a clear indication that the background exposure was changing during the course of the measurements.

MEASUREMENT METHODOLOGY

The December 1998 broadband measurements were made using a Narda, model 8718, electromagnetic survey meter and a Narda, model 8722B,

occupational/controlled exposure conformal electric field probe. The survey meter and probes were calibrated by the manufacturer as a system in February 1998. The individual station measurements made in January 1999 were made with two virtually identical survey instruments consisting of a Narda, model 8718, survey meter and a Narda, model 8761, broadband electric field probe. The additional Narda survey meter and probe were last calibrated as a system on June 3, 1998. Prior to making formal measurements, both survey meters were compared and found to be in reasonable agreement.

All field strength measurements were made at distances far enough removed from the sources being measured to assume the existence of uniform plane wave conditions. Accordingly, no magnetic field strength measurements were deemed necessary to accurately define exposure.

To facilitate the making of average whole body exposure measurements, the survey meters were configured to make one measurement per second for a period of thirty seconds. At the end of the measurement period, the survey meters calculated the average of the thirty measurement values and stored the average measurement values in its internal memory for

later analysis. The survey meter was initialized to display and record measurement data in units of percent of the FCC MPE for occupational/controlled exposure for the 8722B probe and in units of volts squared per meter squared (V^2/m^2) for the 8761 probe.

Average whole body exposure measurements were made at each location by raising the electric field probe to head height, approximately two meters above ground level, initializing the measurement sequence, and then slowly lowering the probe to knee height, approximately one-half meter above ground level. The duration of the probe lowering motion coincided with the survey meter measurement period.

DISCUSSION OF FINDINGS

December 1998 Measurements

As discussed earlier, the purpose of the December 1998 measurements was to determine exposure levels on the observation deck walkway by measuring exposure levels while individual television stations or pairs of television stations used their auxiliary antennas. While the measurements were being made, the other television and FM broadcast stations at WTC1 remained in their normal operating mode. Figure 2 of this

report is a tabulation of measured exposure data for the nine points measured during the survey. The location of each point specified in the tabulation of Figure 2 is identified in the diagram of Figure 5 of this report.

Due to the broad range of frequencies in use by the multiple broadcast stations at WTC1, exposure measurements had to be made employing a survey probe that conforms to the FCC exposure guideline. However, the only probe available at the time of the measurements was a probe that conforms to the MPE for occupational/controlled exposure. Since the environment on the observation deck walkway is classified based on the more restrictive MPE for general population/uncontrolled exposure, the measurement data had to be re-referenced to the more restrictive MPE in order to obtain meaningful results for the general population/uncontrolled environment at WTC2. At the broadcast frequencies in use at WTC1, the FCC MPEs for general population/uncontrolled exposure are five times more restrictive than the FCC MPE for occupational/controlled exposure. Thus, the second tabulation included in Figure 2 of this report re-references the occupational/controlled exposure measurements into percentages relative to the MPE for general population/uncontrolled environments.

With the exception of one of the points under two operating conditions, exposure levels at all of the measured locations comply with the FCC MPE for general population/uncontrolled exposure. When WABC-TV employs its auxiliary antenna and all other stations are in their normal operating mode, the exposure at point 2A is 111.85 percent of the FCC MPE for general population/uncontrolled exposure. The exposure at the same point is 113.00 percent of the FCC MPE for general population/uncontrolled exposure when WWOR-TV and WNET both switch to their auxiliary antennas. Point 2A corresponds to the location identified in the June 18, 1999, WTC2 report where exposure exceeded the MPE for general population/uncontrolled environments when stations were operating in the auxiliary mode. The auxiliary antennas for WABC-TV, WWOR-TV, and WNET are located relatively low on the mast at WTC1. Additionally, WABC-TV, WWOR-TV, and WNET are all high-band VHF stations which employ higher ERPs than the low-band VHF television stations located on WTC1. It is the combination of the WABC-TV, WWOR-TV, and WNET relatively low auxiliary antenna height and higher ERP that results in higher exposure levels at WTC2 for these stations. However, the exposure levels for these stations do not significantly exceed the MPE for general

population/uncontrolled exposure. This, coupled with the possibility that any error in the occupational/controlled measurement data was amplified when multiplied by a factor of five to arrive at general population/uncontrolled data, warranted further investigation.

January 1999 Measurements

The measurements made in January 1999 were an effort to breakdown the overall exposure on the WTC2 observation deck walkway into individual station contributions. To achieve this, as was described earlier, all of the broadcast stations located on WTC1 and WTC2 went off the air and were brought back on the air individually, first employing the main station antenna and then the auxiliary station antenna (if the station has an auxiliary antenna at WTC1). In total, there were 18 different operational conditions measured at seven locations for a total of 126 measurements. Since the measurements were made with only one broadcast station on the air at a time, the measurements had to be made in rapid succession without the opportunity for analysis between measurements.

At first look, the data collected in January 1999 suggests exposures far in excess of the exposure data collected in December 1988. The sum of the

individual station exposures for the normal and auxiliary modes of operation are shown in the following table. Exposures are expressed as percentages of the FCC MPE for general population/uncontrolled exposure.

Operating Mode	Point 1	Point 1A	Point 1B	Point 2	Point 2A	Point 2B	Point 3
Normal Mode	149.94	152.27	127.89	202.62	236.83	247.32	240.62
Auxiliary Mode	161.24	187.93	182.64	189.93	264.78	288.27	286.02

Table 1. Summation of Measurement Data

The data shown in Table 1 of this report for the normal mode of operation were obtained with all broadcast stations at WTC1 operating using their main antennas. The data shown in the previous table for the auxiliary mode of operation were obtained with those stations with auxiliary antennas at WTC1 using their auxiliary antennas. Further, for the auxiliary mode, WCBS-TV not using its main antenna at WTC1 and was assumed to be using its auxiliary antenna at the Empire State Building, and the UHF stations at WTC1 were off the air.

It is evident that measured exposure levels for the normal operating mode are much higher than expected at all of the measurement locations. When compared to the measurement data from December 1998,

increases in exposure of over 100 percentage points are observed. As discussed earlier, this suggests a significant amount of background exposure from other nearby nonbroadcast stations.

In an effort to further examine the validity of the measurement data, exposure predictions were made at each measurement location for each of the operating modes. Where available, manufacturer's antenna data were employed to determine the ERP toward each target point. However, in many cases it was necessary to use approximations. The results of this comparison are in presented in graphical form in Figure 4 of this report. Each graph shows the calculated and measured data for each mode of operation. In virtually all cases, the measured exposure is higher than the calculated exposure indicating that possibly other radio-frequency sources were present and contributing to the exposure at the measurement points.

For each mode of operation surveyed, a trace was saved on a spectrum analyzer. The spectrum analyzer input was connected to a broadband biconic antenna placed in the center of the north observation deck walkway. The spectrum analyzer traces are included as Figure 6 of this report for each operational mode measured. The traces are uncorrected for

antenna gain and are included to illustrate the presence of a significant number of other radio-frequency sources while the survey measurements were being made.

RECOMMENDATIONS FOR FUTURE STUDIES

Since the initial objective of finding procedures by which the television stations operating from WTC1 could employ either the normal or auxiliary mode of operation without causing exposures in excess of the FCC MPE for general population/uncontrolled exposure on the observation deck walkway of WTC2 has not been achieved, further study is warranted. Descriptions of the next two steps recommended for further study follow.

The first step involves use of a new measurement probe recently made available to this firm by Narda. This probe, a Narda, model B8742D, is a shaped probe that conforms to the FCC MPE for general population/uncontrolled exposure.[2] The probe has a dynamic range of 30 dB,

[2] Up until the Narda, model B8742D, conformal electric field probe became available for use in measuring general population/uncontrolled exposures, a Narda, model 8722B, conformal electric field probe was used. Data obtained using the Narda, 8722B probe is expressed in terms of the MPE limit for occupational/controlled exposures and is divided by a factor of 5 to change the data reference to the MPE limit for general population/uncontrolled exposures.

which permits measurement of exposure levels from 0.6 percent to 600 percent of the FCC MPE for general population/uncontrolled exposure. Early experience with the probe indicates that the B8742D probe is much more stable than other conformal probes and has very little zero drift.

It is recommended that the December 1998 course of measurements, in which stations or pairs of stations switched to their auxiliary antennas while the remaining stations remained on the air, be repeated. The only change to the December protocol would be to measure the seven points (1, 1A, 1B, 2, 2A, 2B, 3) on the north walkway measured in January 1999 instead of all nine points around the walkway since previous measurements localized the exposure excursion to the north walkway. If exposures in excess of the MPE for general population/uncontrolled exposure are confirmed, then scenarios for reducing power can be explored and tested.

If the first step survey does not show exposure to be below the MPE limit for general population/uncontrolled exposures, the next recommended step involves employing a wide-band calibrated isotropic sensor with a constant antenna factor to characterize all of the RF energy incident upon the WTC2 outdoor observation deck walkway. The output of the sensor is

connected through a fiber optic cable to a computer-based receiver. The receiver converts the optical information back to radio-frequency energy that can be viewed on a spectrum analyzer. Employing the features of the spectrum analyzer to collect and store data points, an accurate depiction of the spectrum across a wide bandwidth can be achieved. The field strength data points can then be analyzed to determine the exposure contributions within specified bandwidths. This technique offers the ability to provide greater resolution of exposure data and provides the ability to breakdown exposure from multiple sources into individual station contributions. However, this technique will require time to develop and test. Since the equipment is not as suited to field use as other survey equipment, it will very likely take longer to collect and analyze the data.

CONCLUSIONS

The measurement surveys made at WTC2 have each produced vital information that has furthered the understanding of the complex radio-frequency exposure environment at WTC2. The December 1998 measurements clearly highlighted the auxiliary operating conditions under which the FCC MPEs for general population/uncontrolled exposure were

exceeded on the observation deck walkway of WTC2. The December 1998 data show that the FCC MPE for general population/uncontrolled exposure is only exceeded when WABC-TV, WWOR-TV, and WNET employ their auxiliary antennas. The January 1999 measurements, when analyzed as the worst-case, demonstrate that the auxiliary operations of WABC-TV, WWOR-TV, and WNET are not singularly responsible for the FCC MPE for general population/uncontrolled exposure being exceeded on the observation deck walkway at WTC2.

Further investigation of the WTC2 exposure levels is warranted. Since the initial objective of identifying procedures by which the broadcast stations at WTC1 can employ either their main or auxiliary antennas without exceeding the FCC MPE for general population/uncontrolled environments on the observation deck walkway at WTC2 has not been achieved and new instrumentation is available that is capable of measuring exposure directly in units of percent of the FCC MPE for general population/uncontrolled environments, additional studies will permit broadcasters at WTC1 to move closer and ultimately fulfil their objective of assuring compliance with the FCC Rules.

Robert W. Denny, Jr., P.E.

Alan R. Rosner, P.E.

March 17, 1999

Figure 1

ENGINEERING REPORT
ELECTROMAGNETIC FIELD STRENGTH SURVEY AT THE SOUTH TOWER OF THE WORLD TRADE CENTER

TV & FM STATIONS OPERATING AT THE WORLD TRADE CENTER

1. WCBS-TV, New York, New York
   Ch. 2, 21.4 kW (Max-BT), 482 m

2. WNBC(TV), New York, New York
   Ch. 4, 17.4 kW, 515 m

3. WNYW(TV), New York, New York
   Ch. 5, 17.4 kW, 515 m

4. WABC-TV, New York, New York
   Ch. 7, 64.6 kW (Max-BT), 491 m

5. WWOR-TV, Secaucus, New Jersey
   Ch. 9, 61.7 kW (Max-BT), 500 m

6. WPIX(TV), New York, New York
   Ch. 11, 58.9 kW (Max-BT), 506 m

7. WNET(TV), Newark, New Jersey
   Ch. 13, 60.3 kW (Max-BT), 500 m

8. WPXN-TV, New York, New York
   Ch. 31, 2820 kW (Max-DA, BT), 475 m
   Appl.: BPCT-961205KF
   Ch. 31, 5000 kW (Max-DA, BT), 475 m

9. WNJU(TV), Linden, New Jersey
   Ch. 47, 4570 kW (Max-DA, BT), 460 m

10. W60AI[1], New York, New York
    Ch. 60, 45.5 kW (Max-DA), 436 m

11. WKCR-FM, New York, New York
    Ch. 210B1, 0.63 kW (H&V), 433 m

12. WPAT-FM, Paterson, New Jersey
    Ch. 226B, 5.4 kW (H&V), 433 m

13. WNYC-FM, New York, New York
    Ch. 230B, 5.4 kW (H&V), 432 m

14. WKTU(FM), Lake Success, New York
    Ch. 278B, 5.4 kW (H&V), 432 m

[1] The W60AI antenna is located on the south tower of the World Trade Center (WTC2).

Figure 2

ENGINEERING REPORT
ELECTROMAGNETIC FIELD STRENGTH SURVEY AT THE SOUTH TOWER OF THE WORLD TRADE CENTER

Percent Occupational/Controlled Exposure Measured 12/17-18/98[1]

Operating Mode	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 2A
All Stations in Normal Mode	6.28	6.03	6.41	0.91	2.80	3.05	8.10	6.20	--
WNBC (CH 4) and WNYW (CH 5) on Auxiliary Antennas	8.10	7.52	7.30	2.29	4.74	3.86	9.21	14.65	--
WABC-TV (CH 7) on Auxiliary Antenna	13.35	11.38	11.58	2.04	5.63	8.35	8.05	12.95	22.37
WWOR-TV (CH 9) and WNET (CH 13) on Auxiliary Antennas	10.81	13.48	13.08	1.46	5.03	5.10	7.91	8.85	22.60
WPIX on Auxiliary Antenna	9.67	12.45	12.62	1.72	5.08	5.16	6.64	9.94	16.70

Calculated Percent General Population/Uncontrolled Exposure[2]

Operating Mode	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 2A
All Stations in Normal Mode	31.40	30.15	32.05	4.55	14.00	15.25	40.50	31.00	-
WNBC (CH 4) and WNYW (CH 5) on Auxiliary Antennas	40.50	37.60	36.50	11.45	23.70	19.30	46.05	73.25	--
WABC-TV (CH 7) on Auxiliary Antenna	66.75	56.90	57.90	10.20	28.15	41.75	40.25	64.75	111.85
WWOR-TV (CH 9) and WNET (CH 13) on Auxiliary Antennas	54.05	67.40	65.40	7.30	25.15	25.50	39.55	44.25	113.00
WPIX on Auxiliary Antenna	48.35	62.25	63.10	8.60	25.40	25.80	33.20	49.70	83.50

[1] See Figure 5 for identification of measurement locations
[2] Calculated from measured occupational/controlled exposure data

ENGINEERING REPORT
ELECTROMAGNETIC FIELD STRENGTH SURVEY
AT THE SOUTH TOWER OF THE
WORLD TRADE CENTER

COMPARISON OF MEASURED AND CALCULATED EXPOSURE DATA

Measurement Point 1

	Measured Data				Calculated Data						
Operating Mode	FCC MPE for GP/UC Exposure (mW/cm²)	Measured Electric Field Strength (V²/m²)	Equivalent Plane Wave Power Density (mW/cm²)	Percent FCC MPE for GP/UC Exposure	Slant Distance to Target (feet)	Depression Angle to Target (deg.)	Horizontal Plane Relative Field Factor	Vertical Plane Relative Field Factor	Total ERP Toward Target[1] (kW)	Equivalent Plane Wave Power Density (mW/cm²)	Percent FCC MPE for GP/UC Exposure
All Stations Off the Air	0.20	115.80	0.0312	15.60	--	--	--	--	--	--	--
WCBS-TV on Main Ant	0.20	77.75	0.0206	10.30	353.1	32.8	0.920	0.160	0.464	0.0007	0.35
WNBC on Main Ant	0.20	108.30	0.0287	14.35	443.7	48.0	0.920	0.350	1.804	0.0016	0.80
WNBC on Aux. Ant	0.20	106.00	0.0281	14.05	305.2	15.4	0.920	0.730	7.848	0.0152	7.60
WNYW on Main Ant	0.20	80.11	0.0212	10.60	443.7	48.0	0.900	0.450	2.854	0.0026	1.30
WNYW on Aux. Ant	0.20	113.10	0.0300	15.00	303.4	14.3	0.660	0.690	3.609	0.0070	3.50
WABC-TV on Main Ant	0.20	98.96	0.0262	13.10	387.6	40.0	1.000*	0.500*	16.150	0.0193	9.65
WABC-TV on Aux. Ant	0.20	240.30	0.0637	31.85	295.1	7.2	0.600	0.980	22.793	0.0471	23.55
WWOR-TV on Main Ant	0.20	84.82	0.0225	11.25	405.2	12.8	1.000*	0.500*	15.425	0.0169	8.45
WWOR-TV on Aux. Ant	0.20	120.10	0.0319	15.95	291.5	1.2	0.580	1.000	16.114	0.0341	17.05
WPIX on Main Ant	0.20	110.70	0.0294	14.70	424.4	45.6	0.740	0.200*	1.351	0.0013	0.65
WPIX on Aux. Ant	0.20	221.40	0.0587	29.35	293.5	5.1	0.540	1.000	17.175	0.0359	17.95
WNET on Main Ant	0.20	186.10	0.0494	24.70	405.2	42.8	1.000*	0.500*	15.075	0.0165	8.25
WNET on Aux. Ant	0.20	160.20	0.0425	21.25	292.7	3.9	0.500	1.000	11.975	0.0251	12.55
WPXN-TV on Main Ant	0.38	122.50	0.0325	8.55	356.5	33.7	0.900	0.150*	51.395	0.0727	19.13
WNJU on Main Ant	0.45	146.00	0.0387	8.60	328.8	25.8	1.000*	0.150*	102.825	0.1711	38.02
W60AI on Main Ant	0.50	89.53	0.0237	4.74							
WTC FM's on Master Ant	0.20	219.10	0.0581	29.05	294.0	5.9	0.700	1.000*	19.727	0.0821	41.05

[1] Calculation of ERP based on manufacturer's horizontal and vertical plane pattern data unless otherwise noted
* Assumed value

Measurement Point 3A

Operating Mode	Measured Data: FCC MPE for GP/UC Exposure (mW/cm²)	Measured Data: Measured Electric Field Strength (V²/m²)	Measured Data: Equivalent Plane Wave Power Density (mW/cm²)	Measured Data: Percent FCC MPE for GP/UC Exposure	Calculated Data: Slant Distance to Target (feet)	Calculated Data: Depression Angle to Target (deg.)	Calculated Data: Horizontal Plane Relative Field Factor	Calculated Data: Vertical Plane Relative Field Factor	Calculated Data: Total ERP Toward Target[1] (kW)	Calculated Data: Equivalent Plane Wave Power Density (mW/cm²)	Calculated Data: Percent FCC MPE for GP/UC Exposure
All Stations Off the Air	0.20	110.70	0.0294	14.70	--	--		--	--	--	--
WCBS-TV on Main Ant	0.20	75.40	0.0200	10.00	361.3	31.7	0.920	0.100	0.181	0.0002	0.10
WNBC on Main Ant	0.20	115.40	0.0306	15.30	452.7	46.7	0.900	0.350	1.727	0.0015	0.75
WNBC on Aux. Ant	0.20	113.10	0.0300	15.00	318.1	14.7	0.980	0.750	9.593	0.0170	8.50
WNYW on Main Ant	0.20	84.82	0.0225	11.25	452.7	46.7	0.880	0.450	2.729	0.0024	1.20
WNYW on Aux. Ant	0.20	96.60	0.0256	12.80	316.4	13.7	0.740	0.720	4.939	0.0089	4.45
WABC-TV on Main Ant	0.20	108.30	0.0287	14.35	397.8	38.7	1.000[2]	0.500[2]	16.150	0.0184	9.20
WABC-TV on Aux. Ant	0.20	230.90	0.0612	30.60	308.4	6.9	0.700	0.990	31.024	0.0587	29.35
WWOR-TV on Main Ant	0.20	70.68	0.0187	9.35	415.0	41.5	1.000[2]	0.500[2]	15.425	0.0161	8.05
WWOR-TV on Aux. Ant	0.20	195.50	0.0519	25.95	305.0	1.1	0.660	1.000	20.865	0.0403	20.15
WPIX on Main Ant	0.20	96.60	0.0256	12.80	433.8	44.3	0.740	0.200[2]	1.351	0.0013	0.65
WPIX on Aux. Ant	0.20	296.80	0.0787	39.35	306.8	4.9	0.620	1.000	22.641	0.0432	21.60
WNET on Main Ant	0.20	183.70	0.0487	24.35	415.0	41.5	1.000[2]	0.500[2]	15.075	0.0157	7.85
WNET on Aux. Ant	0.20	190.80	0.0506	25.30	306.1	3.8	0.600	1.000	17.244	0.0331	16.55
WPXN-TV on Main Ant	0.38	110.70	0.0294	7.74	367.6	32.5	0.900	0.150[2]	51.395	0.0684	18.00
WNJU on Main Ant	0.45	139.00	0.0369	8.20	340.8	24.8	1.000[2]	0.150[2]	102.825	0.1592	35.38
WGOAI on Main Ant	0.50	91.89	0.0244	4.88							
WTC FMs on Master Ant	0.20	256.80	0.0681	34.05	307.4	5.6	0.750	1.000[2]	22.646	0.0862	43.10

[1] Calculation of ERP based on manufacturer's horizontal and vertical plane pattern data unless otherwise noted
[2] Assumed value

Measurement Point 1B

Operating Mode	Measured Data: FCC MPE for GP/UC Exposure (mW/cm²)	Measured Electric Field Strength (V²/m²)	Equivalent Plane Wave Power Density (mW/cm²)	Percent FCC MPE for GP/UC Exposure	Calculated Data: Slant Distance to Target (feet)	Depression Angle to Target (deg.)	Horizontal Plane Relative Field Factor	Vertical Plane Relative Field Factor	Total ERP Toward Target[1] (kW)	Equivalent Plane Wave Power Density (mW/cm²)	Percent FCC MPE for GP/UC Exposure
All Stations Off-the-Air	0.20	101.30	0.0269	13.45	..	.			..	..	..
WCBS-TV on Main Ant	0.20	73.01	0.0194	9.70	377.0	30.5	0.920	0.100	0.181	0.0002	0.10
WNBC on Main Ant	0.20	98.60	0.0262	13.10	463.0	45.3	0.880	0.350	1.651	0.0014	0.70
WNBC on Aux. Ant	0.20	122.50	0.0325	16.25	332.5	14.0	1.000	0.760	10.050	0.0163	8.15
WNYW on Main Ant	0.20	70.68	0.0187	9.35	463.0	45.3	0.860	0.450	2.606	0.0022	1.10
WNYW on Aux. Ant	0.20	101.30	0.0269	13.45	330.9	13.0	0.820	0.740	6.407	0.0105	5.25
WABC-TV on Main Ant	0.20	96.60	0.0256	12.80	409.5	37.3	1.000'	0.500'	16.150	0.0173	8.65
WABC-TV on Aux. Ant	0.20	193.20	0.0512	25.60	323.3	6.6	0.860	0.990	46.827	0.0806	40.30
WWOR-TV on Main Ant	0.20	58.90	0.0156	7.80	426.2	40.2	1.000'	0.500'	15.425	0.0153	7.65
WWOR-TV on Aux. Ant	0.20	294.50	0.0781	39.05	320.1	1.1	0.820	1.000	32.208	0.0565	28.25
WPIX on Main Ant	0.20	58.90	0.0156	7.80	444.5	42.9	0.740	0.200'	1.351	0.0012	0.60
WPIX on Aux. Ant	0.20	221.10	0.0587	29.35	321.8	4.6	0.800	1.000	37.696	0.0654	32.70
WNET on Main Ant	0.20	139.00	0.0369	18.45	426.2	40.2	1.000'	0.500'	15.075	0.0149	7.45
WNET on Aux. Ant	0.20	195.50	0.0519	25.95	321.2	3.6	0.800	1.000	30.656	0.0534	26.70
WPXN-TV on Main Ant	0.38	96.60	0.0256	6.74	380.2	31.2	0.840	0.150'	44.770	0.0557	14.66
WNJU on Main Ant	0.45	155.50	0.0412	9.16	354.3	23.8	1.000'	0.150'	102.825	0.1473	32.73
W60AI on Main Ant	0.50	127.20	0.0337	6.74							
WTC FMs on Master Ant	0.20	197.90	0.0525	26.25	322.3	5.4	0.800	1.000'	25.766	0.0892	44.60

[1] Calculation of ERP based on manufacturer's horizontal and vertical plane pattern data unless otherwise noted
' Assumed value

X

Measurement Point 2

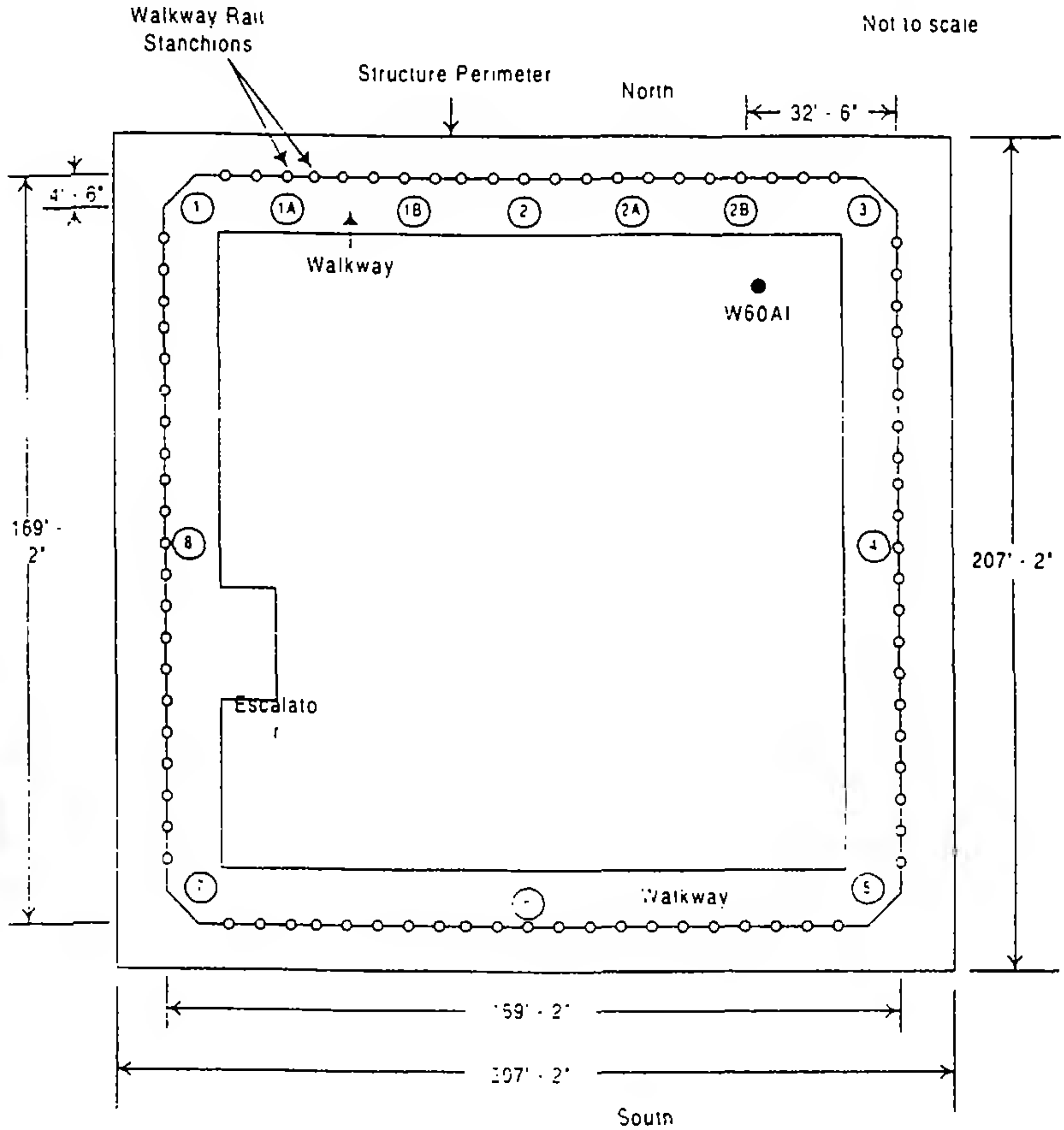
Operating Mode	Measured Data: FCC MPE for GP/UC Exposure (mW/cm²)	Measured Data: Measured Electric Field Strength (V²/m²)	Measured Data: Equivalent Plane Wave Power Density (mW/cm²)	Measured Data: Percent FCC MPE for GP/UC Exposure	Calculated Data: Slant Distance to Target (feet)	Calculated Data: Depression Angle to Target (deg.)	Calculated Data: Horizontal Plane Relative Field Factor	Calculated Data: Vertical Plane Relative Field Factor	Calculated Data: Total ERP Toward Target[1] (kW)	Calculated Data: Equivalent Plane Wave Power Density (mW/cm²)	Calculated Data: Percent FCC MPE for GP/UC Exposure
All Stations Off-the-Air	0.20	161.90	0.0437	21.85	--	--	--	--	--	--	--
WCBS-TV on Main Ant	0.20	143.70	0.0381	19.05	301.1	29.2	0.920	0.110	0.219	0.0003	0.15
WNBC on Main Ant	0.20	172.00	0.0456	22.80	474.6	43.8	0.880	0.350	1.651	0.0013	0.65
WNBC on Aux. Ant	0.20	116.00	0.0387	19.35	348.5	13.4	1.000	0.790	10.859	0.0161	8.05
WNYW on Main Ant	0.20	118.40	0.0394	19.70	474.6	43.8	0.850	0.450	2.546	0.0020	1.00
WNYW on Aux. Ant	0.20	157.80	0.0419	20.95	347.0	12.4	0.880	0.760	7.783	0.0116	5.80
WABC-TV on Main Ant	0.20	179.00	0.0475	23.75	422.5	36.0	1.000*	0.500*	16.150	0.0163	8.15
WABC-TV on Aux. Ant	0.20	201.90	0.0612	30.60	339.7	6.3	0.950	0.990	58.351	0.0909	45.45
WWOR-TV on Main Ant	0.20	186.10	0.0494	24.70	438.8	38.8	1.000*	0.500*	15.425	0.0144	7.20
WWOR-TV on Aux. Ant	0.20	226.20	0.0600	30.00	336.6	1.0	0.910	1.000	42.321	0.0672	33.60
WPIX on Main Ant	0.20	73.04	0.0194	9.70	456.6	41.4	0.750	0.200*	1.388	0.0012	0.60
WPIX on Aux. Ant	0.20	161.90	0.0437	21.85	338.3	4.4	0.940	1.000	52.044	0.0818	40.90
WNET on Main Ant	0.20	143.70	0.0381	19.05	438.8	38.8	1.000*	0.500*	15.075	0.0141	7.05
WNET on Aux. Ant	0.20	216.70	0.0575	28.75	337.7	3.4	0.920	1.000	40.643	0.0639	31.95
WPXN-TV on Main Ant	0.38	169.60	0.0450	11.84	394.2	30.0	0.840	0.150*	44.770	0.0518	13.63
WNJU on Main Ant	0.45	230.90	0.0612	13.60	369.3	22.7	1.000*	0.150*	102.825	0.1355	30.11
W60AI on Main Ant	0.50	129.50	0.0344	6.88							
WTC FMs on Master Ant	0.20	237.90	0.0631	31.55	338.8	5.1	0.830	1.000*	27.735	0.0869	43.45

[1] Calculation of ERP based on manufacturer's horizontal and vertical plane pattern data unless otherwise noted
* Assumed value

Figure 5

MARCH 1999

Notes:
1. Measurement locations are indicated by circled numbers and letters. e.g. 1A
2. Observation deck walkway is approximately 9 feet above building roof level.

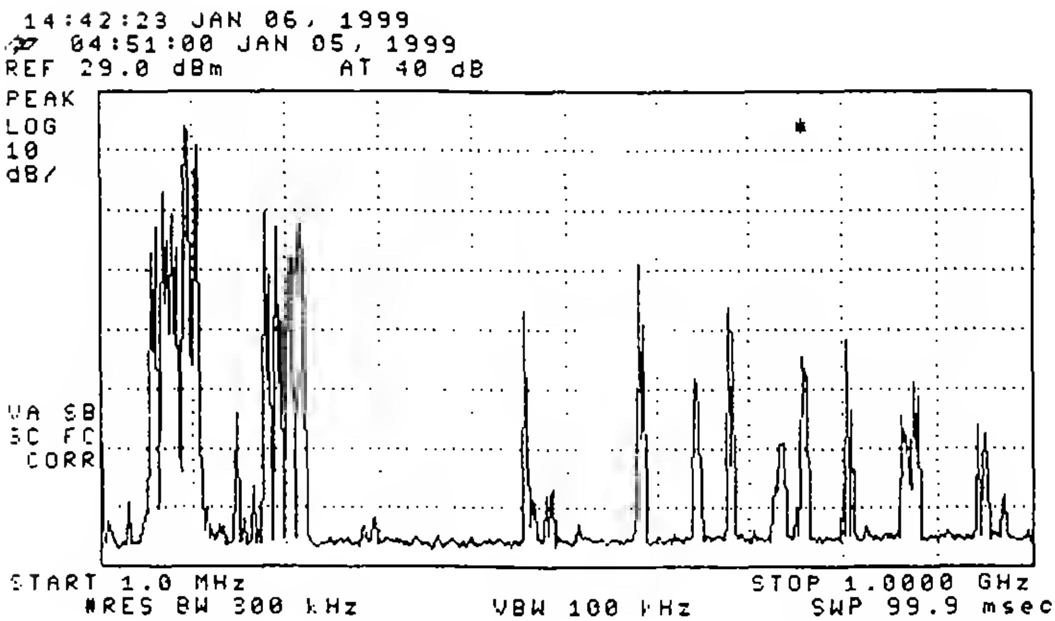


MEASUREMENT LOCATIONS
WORLD TRADE CENTER
SOUTH TOWER ROOFTOP OBSERVATION DECK WALKWAY

Denny & Associates, P.C. Consulting Engineers

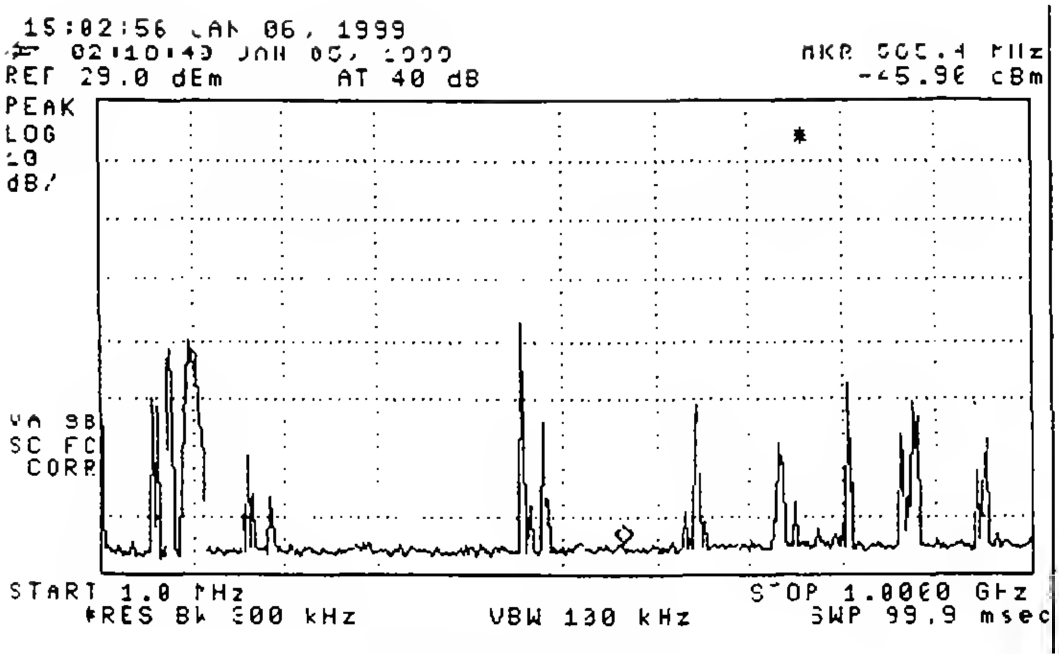
ENGINEERING REPORT
ELECTROMAGNETIC FIELD STRENGTH SURVEY
AT THE SOUTH TOWER OF THE
WORLD TRADE CENTER

SPECTRUM ANALYZER PLOTS FOR
SINGLE-STATION MEASUREMENT PERIODS

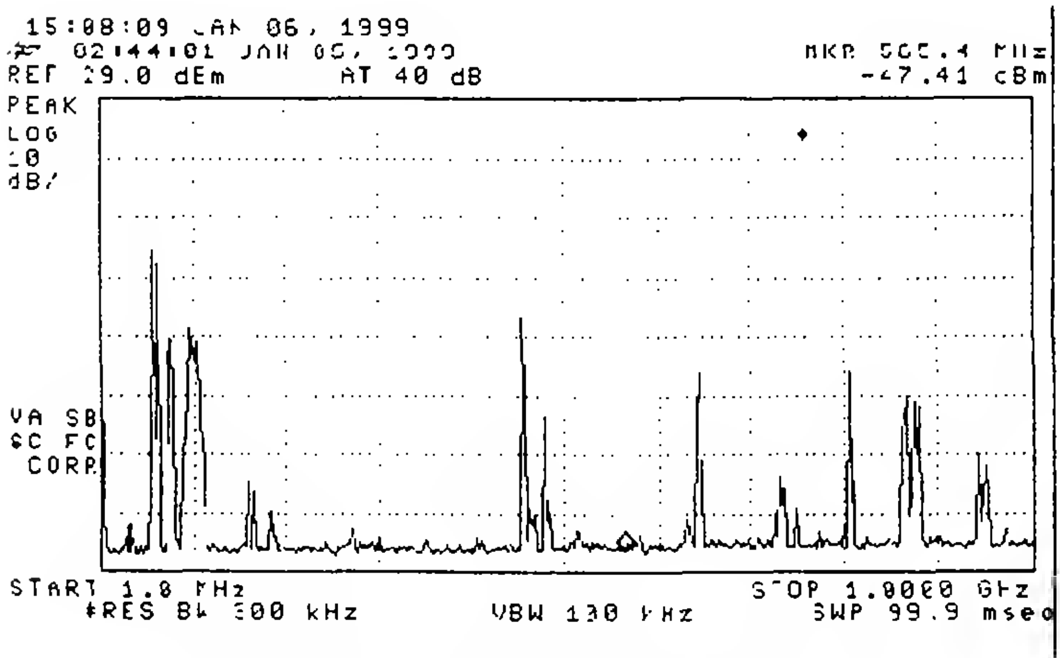


All WTC Stations in Normal Operating Mode

Figure 6
Sheet 2 of 10

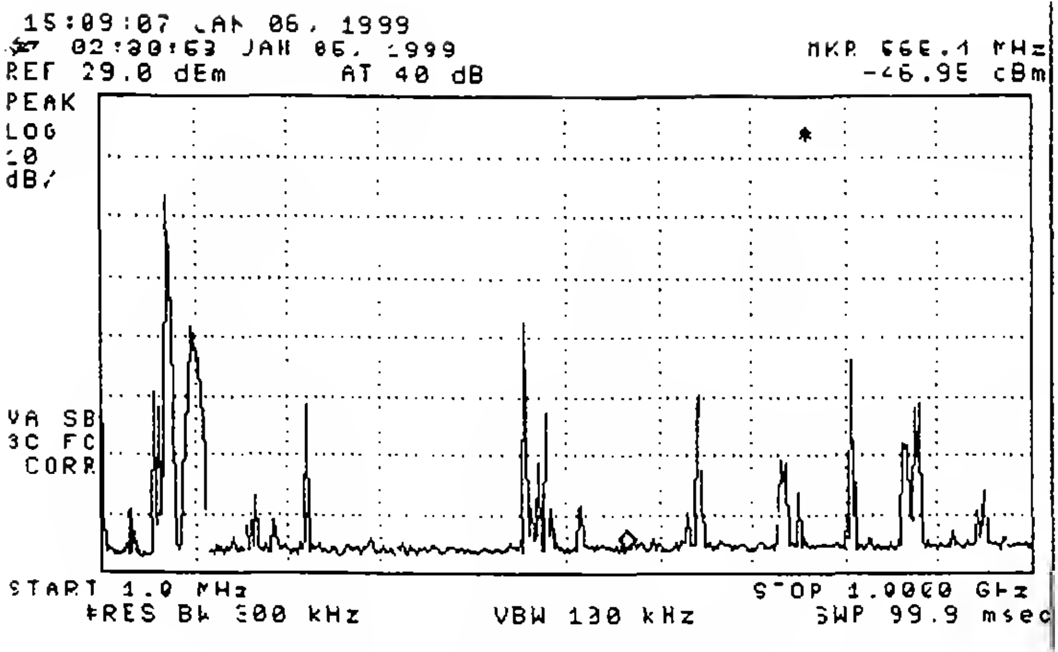


All WTC Stations Off-the-Air

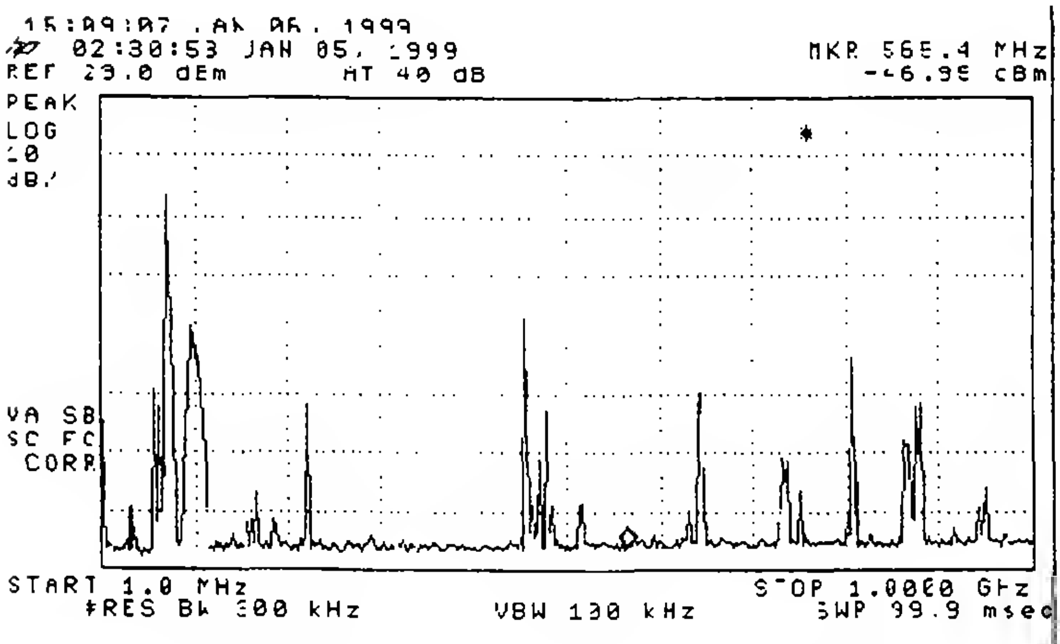


WCBS-TV (54-60 MHz) Operating with Main Antenna

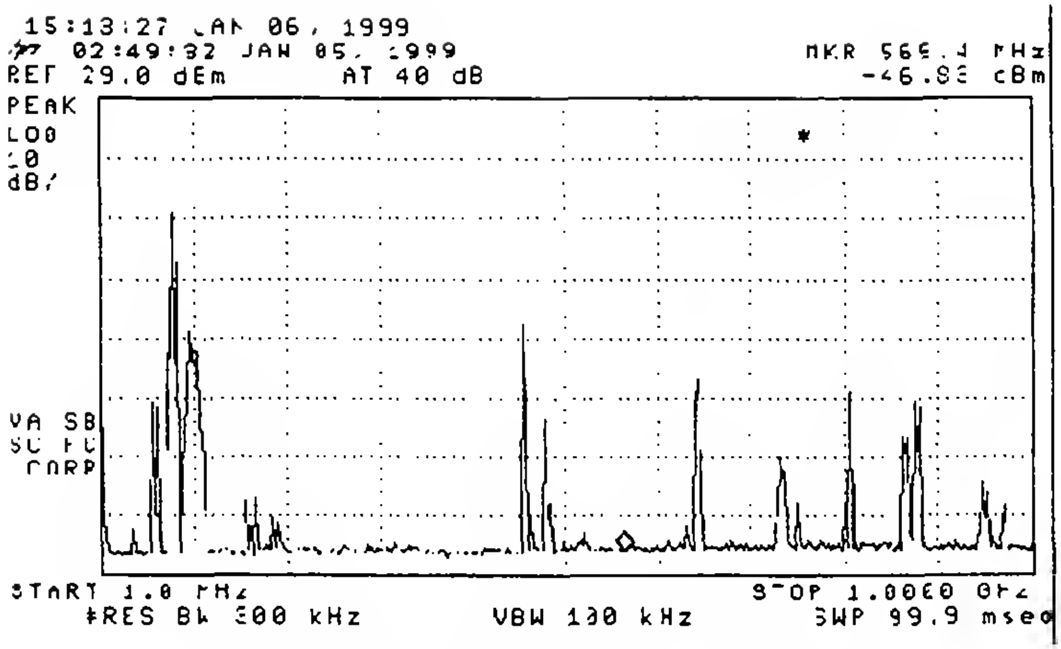
Figure 6
Sheet 3 of 10



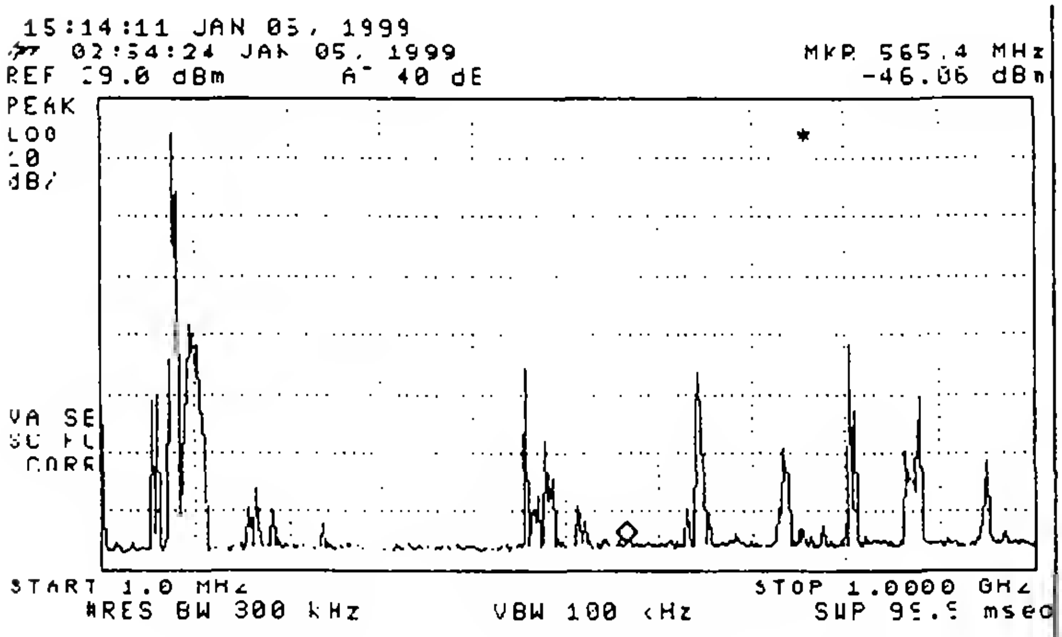
WNBC (66-72 MHz) Operating with Main Antenna



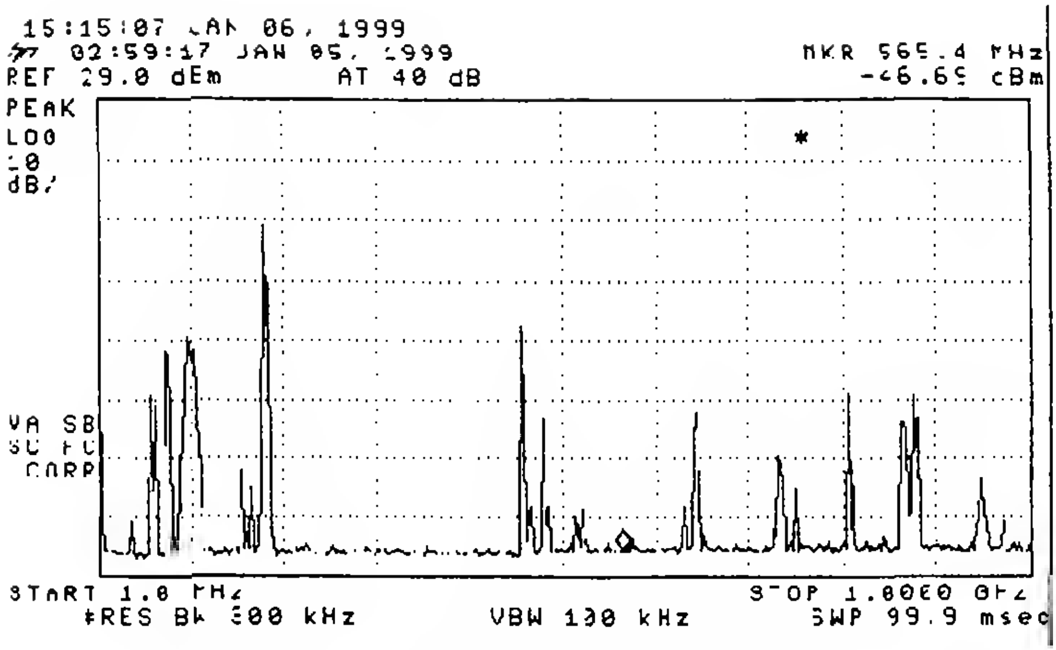
WNBC (66-72 MHz) Operating with Auxiliary Antenna



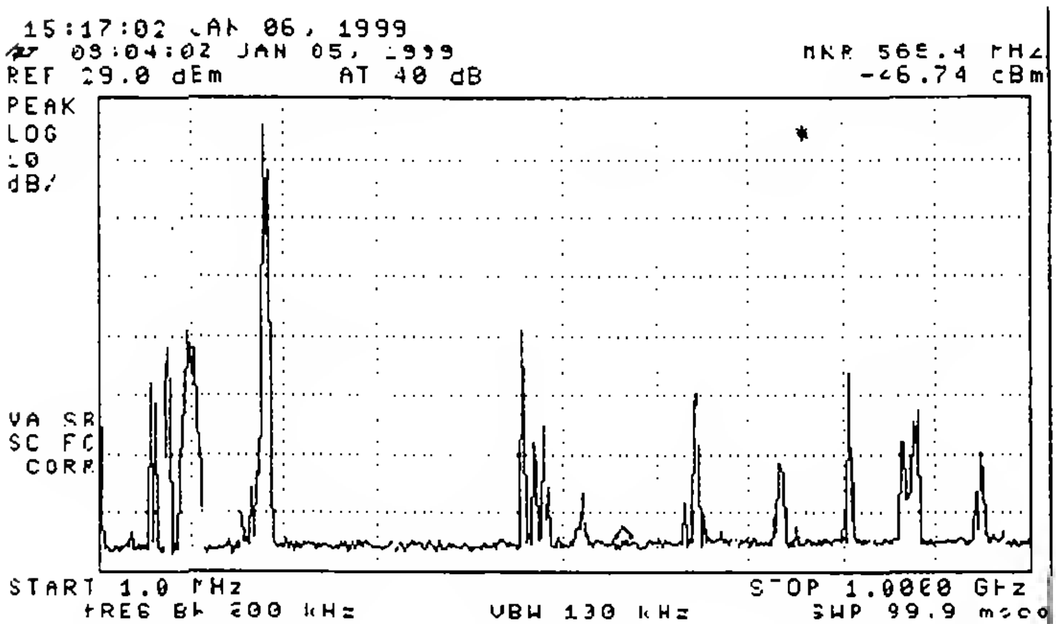
WNYW (76-82 MHz) Operating with Main Antenna



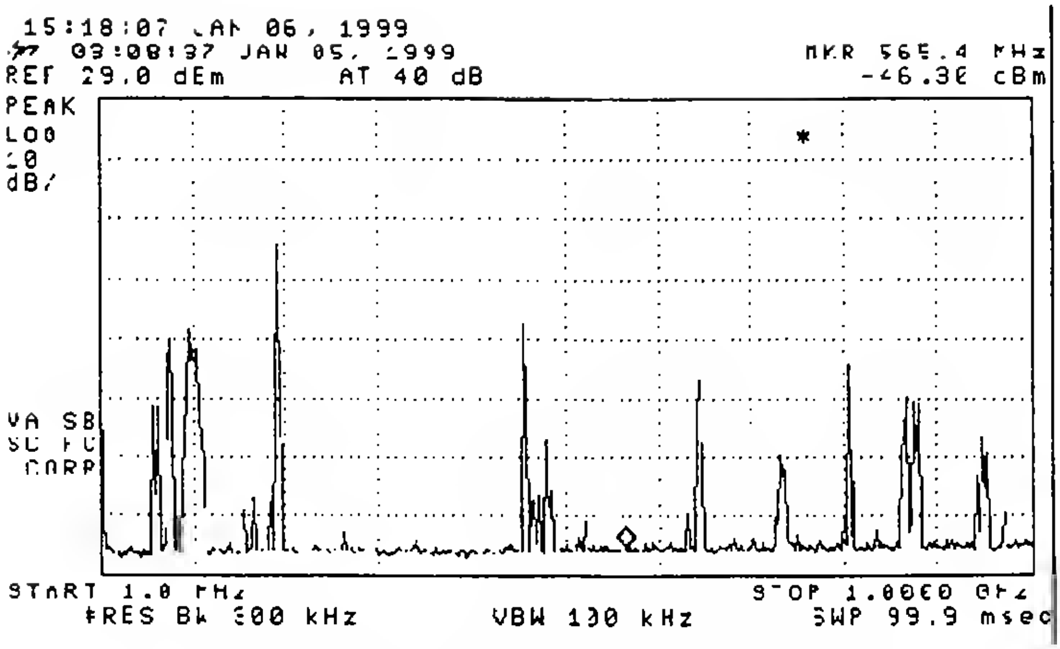
WNYW (76-82 MHz) Operating with Auxiliary Antenna



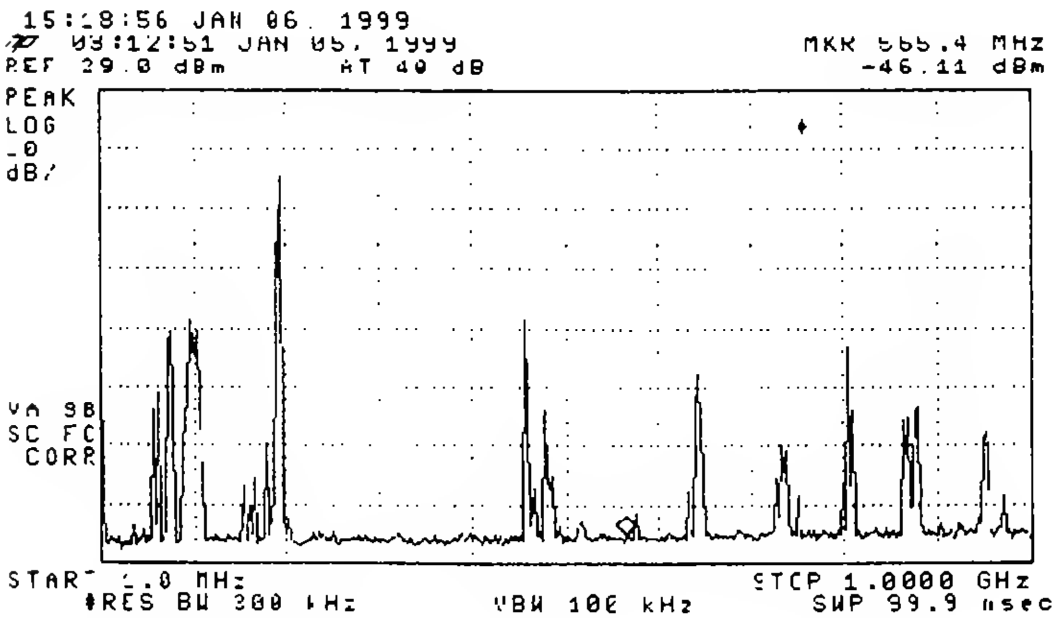
WABC-TV (174-180 MHz) Operating with Main Antenna



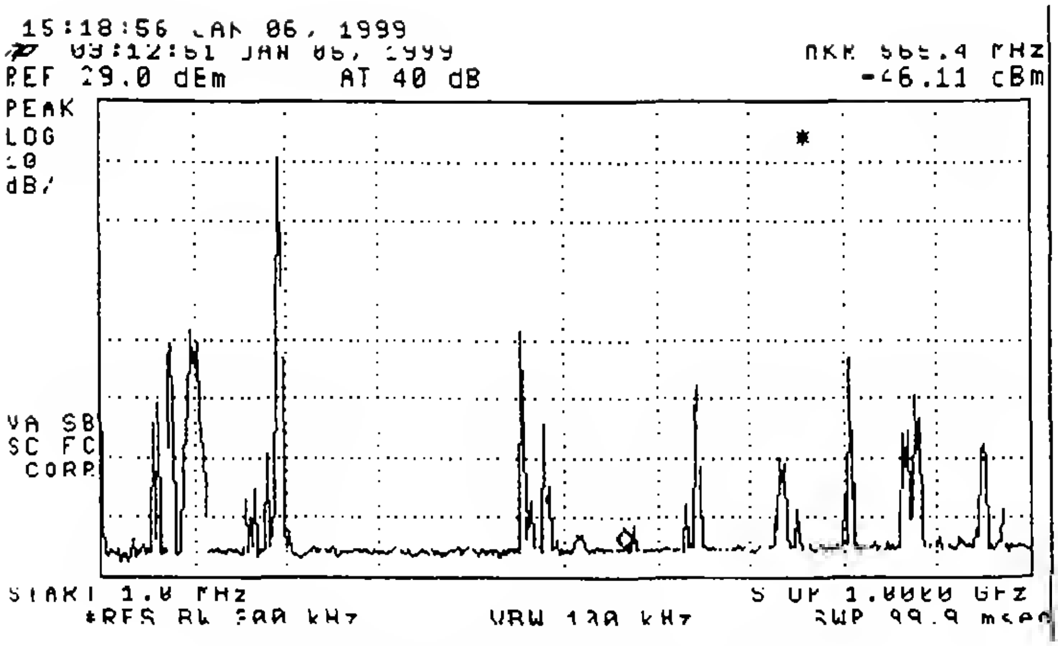
WABC-TV (174-180 MHz) Operating with Auxiliary Antenna



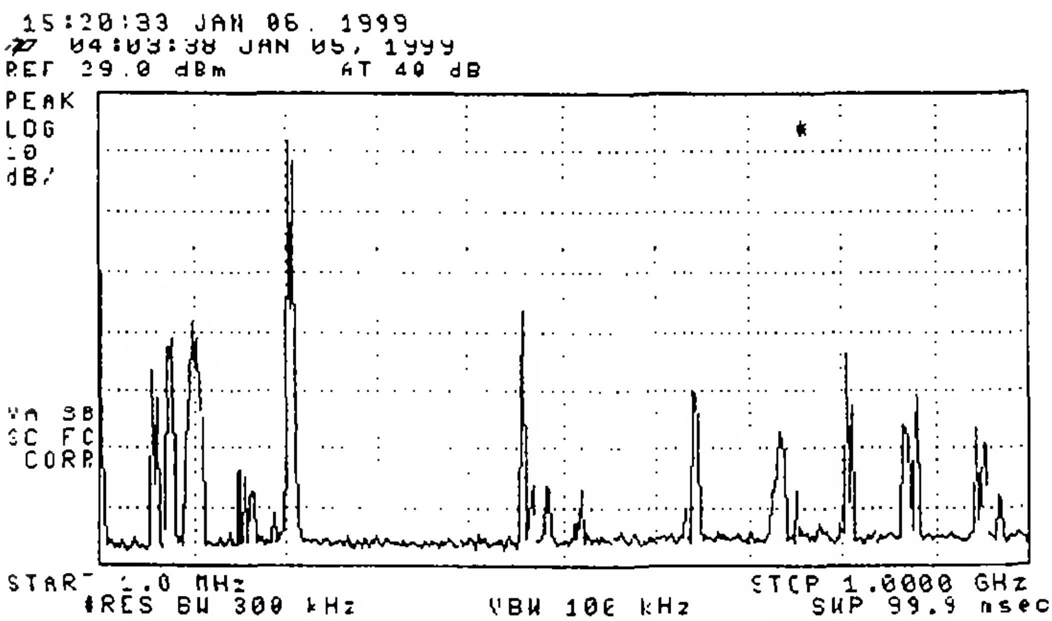
WWOR-TV (186-192 MHz) Operating with Main Antenna



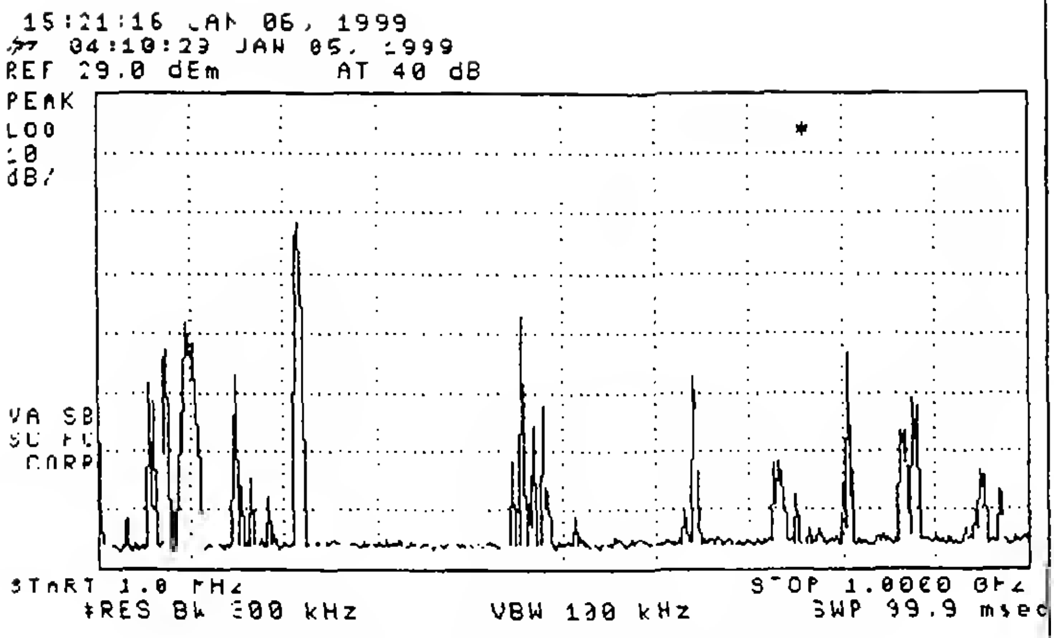
WWOR-TV (186-192 MHz) Operating with Auxiliary Antenna



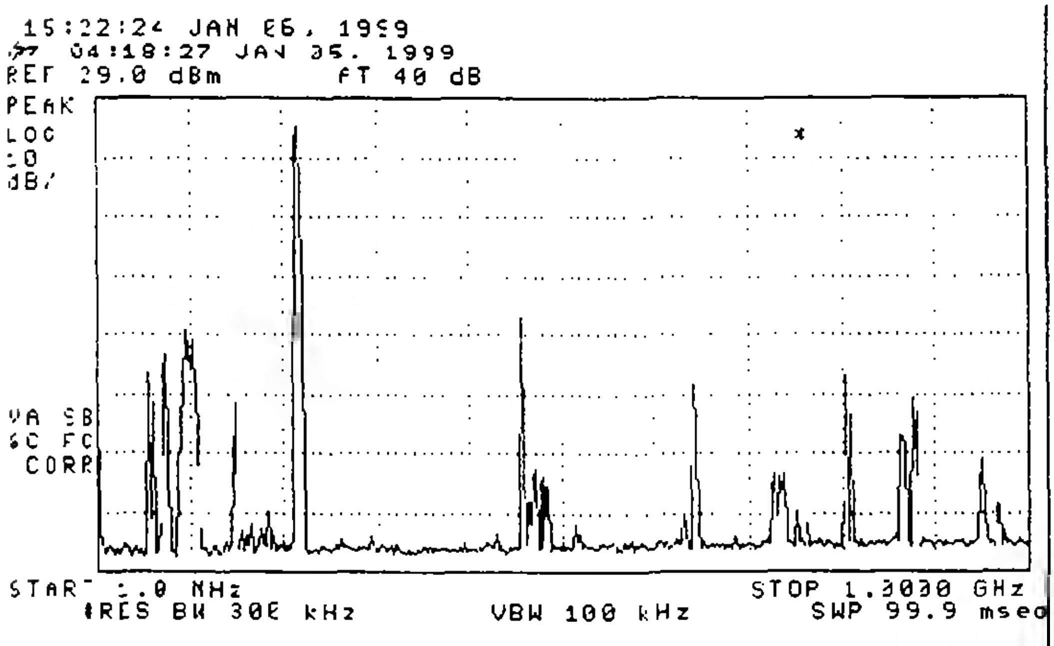
WPIX (198-204 MHz) Operating with Main Antenna



WPIX (198-204 MHz) Operating with Auxiliary Antenna

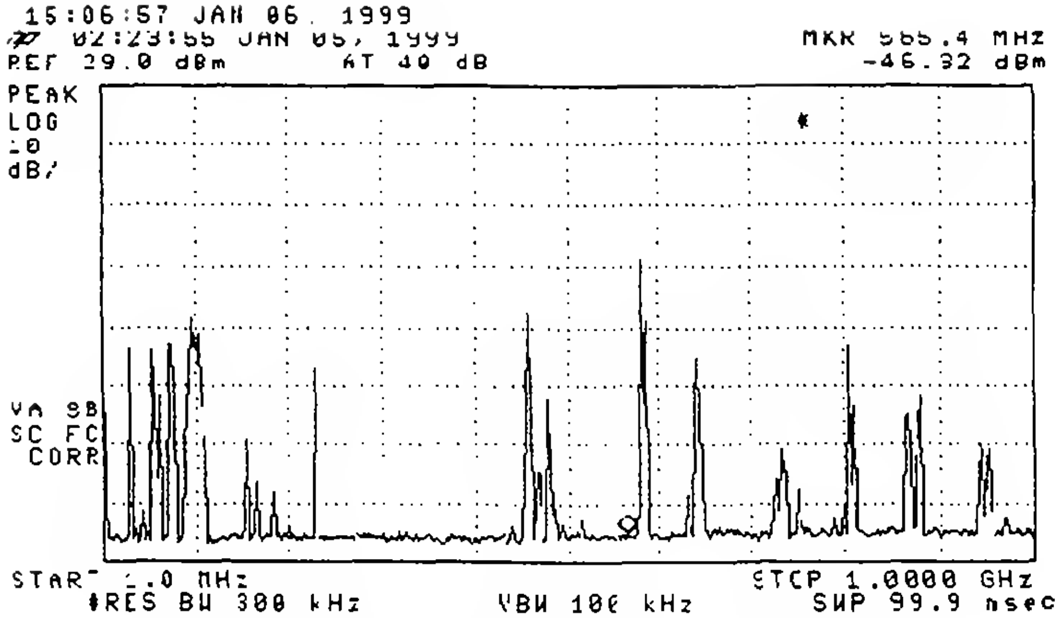


WNET (210-216 MHz) Operating with Main Antenna

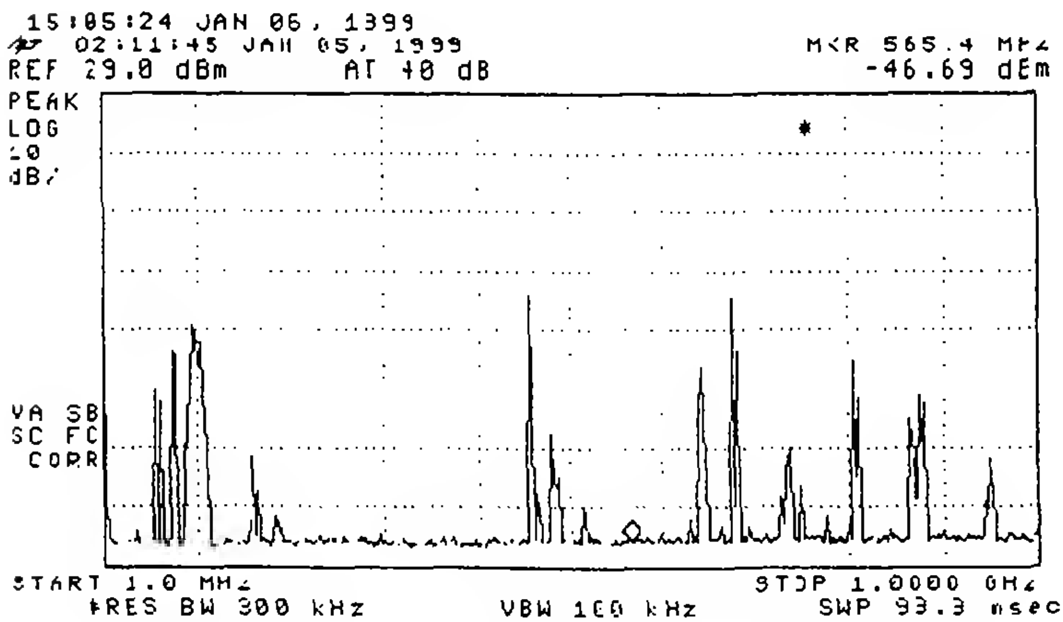


WNET (210-216 MHz) Operating with Auxiliary Antenna

Figure 6
Sheet 9 of 10

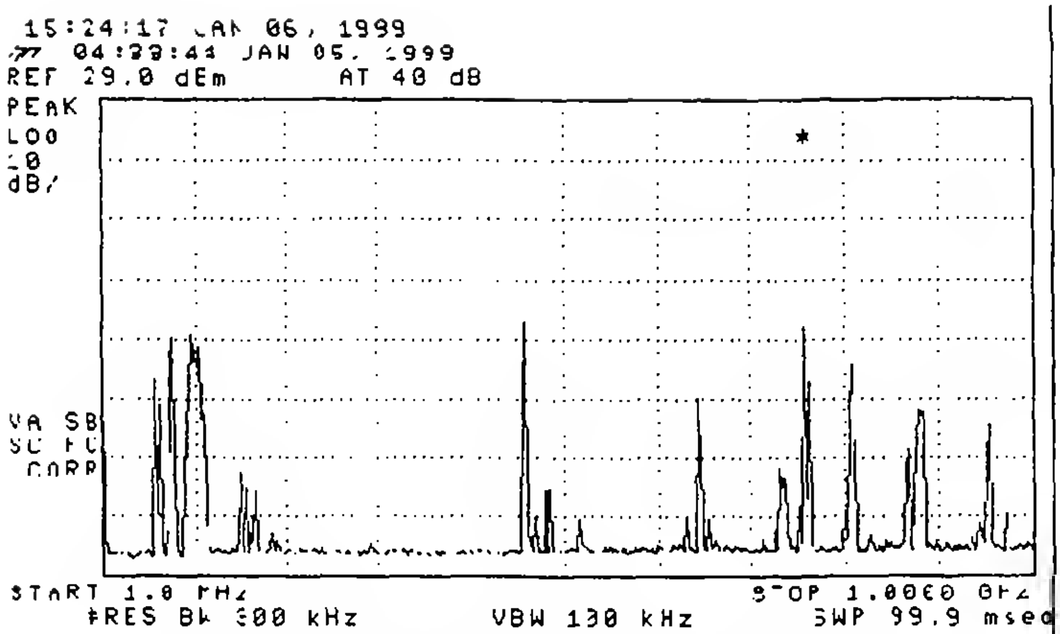


WPXN-TV (572-578 MHz) Operating with Main Antenna

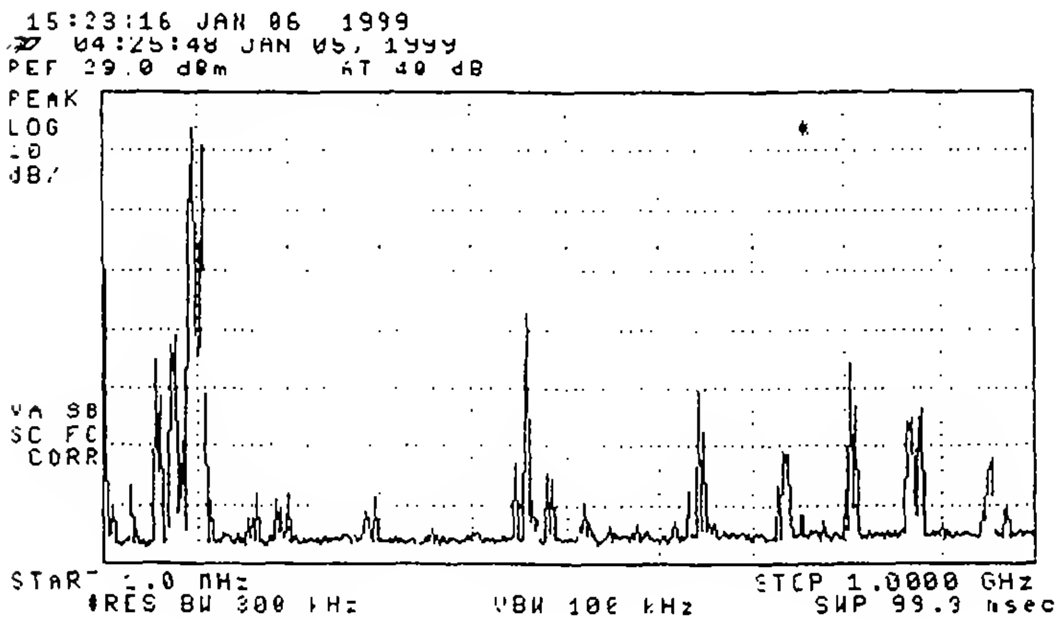


WNJU (668-674 MHz) Operating with Main Antenna

Figure 6
Sheet 10 of 10



W60AI (746-752 MHz) Operating with Main Antenna



WTC FM Stations Operating into Master Antenna

Measurement Point 2A

Operating Mode	Measured Data: FCC MPE for GP/UC Exposure (mW/cm²)	Measured Data: Measured Electric Field Strength (V²/m²)	Measured Data: Equivalent Plane Wave Power Density (mW/cm²)	Measured Data: Percent FCC MPE for GP/UC Exposure	Calculated Data: Slant Distance to Target (feet)	Calculated Data: Depression Angle to Target (deg.)	Calculated Data: Horizontal Plane Relative Field Factor	Calculated Data: Vertical Plane Relative Field Factor	Calculated Data: Total ERP Toward Target[1] (kW)	Calculated Data: Equivalent Plane Wave Power Density (mW/cm²)	Calculated Data: Percent FCC MPE for GP/UC Exposure
All Stations Off (Ins-An	0.20	228.5	0.0606	30.30	..	..	..	..	..	..	..
WCBS-TV on Main Ant	0.20	169.6	0.0450	22.50	406.6	28.0	0.920	0.150	0.408	0.0004	0.20
WNBC on Main Ant	0.20	188.5	0.0500	25.00	487.4	42.4	0.880	0.350	1.651	0.0012	0.60
WNBC on Aux. Ant	0.20	179	0.0475	23.75	365.7	12.7	0.960	0.800	10.263	0.0138	6.90
WNYW on Main Ant	0.20	174.3	0.0462	23.10	487.4	42.1	0.810	0.450	2.486	0.0019	0.95
WNYW on Aux. Ant	0.20	214.4	0.0569	28.45	364.3	11.8	0.950	0.780	9.554	0.0129	6.45
WABC-TV on Main Ant	0.20	186.1	0.0494	24.70	436.8	33.6	1.000*	0.500*	16.150	0.0162	7.60
WABC-TV on Aux. Ant	0.20	306.3	0.0812	40.60	357.3	6.0	1.000	0.990	63.314	0.0892	44.60
WWOR-TV on Main Ant	0.20	179	0.0475	23.75	452.6	47.3	1.000*	0.500*	15.425	0.0135	6.75
WWOR-TV on Aux. Ant	0.20	381.7	0.1012	50.60	354.4	1.0	1.000	1.000	47.900	0.0686	34.30
WPIX on Main Ant	0.20	113.1	0.0300	15.00	469.9	40.0	0.780	0.200*	1.502	0.0012	0.60
WPIX on Aux. Ant.	0.20	263.9	0.0700	35.00	356.0	4.2	1.000	1.000	58.900	0.0836	41.80
WNET on Main Ant	0.20	155.5	0.0412	20.60	452.6	37.3	1.000*	0.500*	16.075	0.0132	6.60
WNET on Aux. Ant	0.20	245	0.0650	32.50	355.4	3.2	1.000	1.000	47.900	0.0682	34.10
WPXN-TV on Main Ant	0.38	214.4	0.0569	14.97	409.5	28.7	0.800	0.150	40.608	0.0435	11.45
WNJU on Main Ant	0.45	226.2	0.0600	13.33	385.6	21.7	1.000*	0.150*	102.825	0.1243	27.62
WGAI on Main Ant	0.50	167.2	0.0444	8.88							
WTC FM's on Master Ant	0.20	339.3	0.0900	45.00	356.5	4.8	0.830	1.000*	27.735	0.0785	39.25

[1] Calculation of ERP based on manufacturer's horizontal and vertical plane pattern data unless otherwise noted.
* Assumed value.

Measurement Point 2B

Operating Mode	Measured Data: FCC MPE for GP/UC Exposure (mW/cm²)	Measured Electric Field Strength (V²/m²)	Equivalent Plane Wave Power Density (mW/cm²)	Percent FCC MPE for GP/UC Exposure	Calculated Data: Slant Distance to Target (feet)	Depression Angle to Target (deg.)	Horizontal Plane Relative Field Factor	Vertical Plane Relative Field Factor	Total ERP Toward Target[1] (kW)	Equivalent Plane Wave Power Density (mW/cm²)	Percent FCC MPE for GP/UC Exposure
All Stations Off the Air	0.20	197.9	0.0525	26.25	--	-		-	--	--	--
WCBS-TV on Main Ant	0.20	155.5	0.0412	20.60	423.0	26.8	0.920	0.170	0.523	0.0005	0.25
WNBC on Main Ant	0.20	186.1	0.0494	24.70	501.2	40.9	0.880	0.350	1.651	0.0012	0.60
WNBC on Aux. Ant	0.20	160.2	0.0425	21.25	381.0	12.1	0.920	0.820	9.903	0.0121	6.05
WNYW on Main Ant	0.20	160.2	0.0425	21.25	501.2	40.9	0.840	0.450	2.486	0.0018	0.90
WNYW on Aux. Ant	0.20	197.9	0.0525	26.25	382.6	11.2	0.980	0.800	10.695	0.0131	6.55
WABC-TV on Main Ant	0.20	188.5	0.0500	25.00	452.2	33.2	1.000*	0.500*	16.150	0.0142	7.10
WABC-TV on Aux. Ant	0.20	388.7	0.1031	51.55	376.0	5.7	1.000	1.000	64.600	0.0822	41.10
WWOR-TV on Main Ant	0.20	174.1	0.0462	23.10	467.4	35.9	1.000*	0.500*	15.425	0.0127	6.35
WWOR-TV on Aux. Ant	0.20	393.6	0.1044	52.20	373.2	0.9	1.000	1.000	17.900	0.0618	30.90
WPIX on Main Ant	0.20	131.9	0.0350	17.50	484.2	38.5	0.780	0.200*	1.502	0.0012	0.60
WPIX on Aux. Ant	0.20	280.3	0.0744	37.20	374.7	4.0	1.000	1.000	58.900	0.0754	37.70
WNET on Main Ant	0.20	195.5	0.0519	25.95	467.4	35.9	1.000*	0.500*	15.075	0.0124	6.20
WNET on Aux. Ant	0.20	278	0.0737	36.85	374.2	3.1	1.000	1.000	47.900	0.0615	30.75
WPXN-TV on Main Ant	0.38	193.2	0.0512	13.47	425.9	27.5	0.900	0.150*	51.395	0.0509	13.39
WNJU on Main Ant	0.45	216.7	0.0575	12.78	400.0	20.7	1.000*	0.150*	102.825	0.1139	25.31
W40AI on Main Ant	0.50	303.9	0.0806	16.12							
WTC FMs on Master Ant	0.20	353.1	0.0937	46.85	375.1	4.6	0.830	1.000*	27.735	0.0709	35.45

[1] Calculation of ERP based on manufacturer's horizontal and vertical plane pattern data unless otherwise noted
* Assumed value

Measurement Point 4

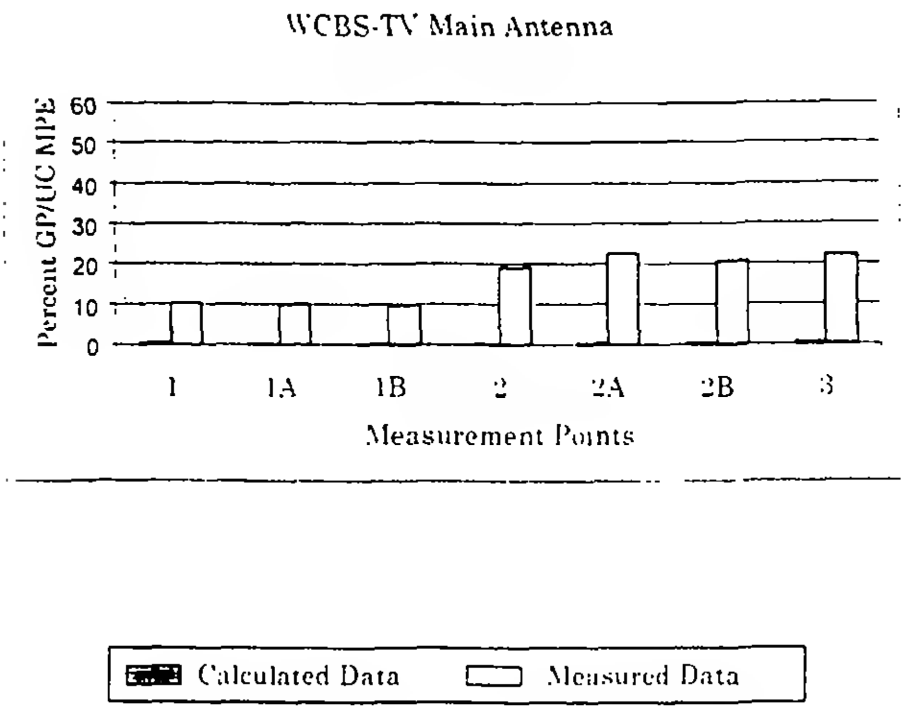
Operating Mode	FCC MPE for GP/UC Exposure (mW/cm²)	Measured Electric Field Strength (V²/m²)	Equivalent Plane Wave Power Density (mW/cm²)	Percent FCC MPE for GP/UC Exposure	Slant Distance to Target (feet)	Depression Angle to Target (deg.)	Horizontal Plane Relative Field Factor	Vertical Plane Relative Field Factor	Total ERP Toward Target[1] (kW)	Equivalent Plane Wave Power Density (mW/cm²)	Percent FCC MPE for GP/UC Exposure
	Measured Data				Calculated Data						
All Stations Off the Air	0.20	244.30	0.0569	28.45						--	--
WCBS-TV on Main Ant	0.20	164.90	0.0437	21.85	440.6	25.6	0.910	0.200	0.709	0.0007	0.35
WNBC on Main Ant	0.20	183.70	0.0487	24.35	516.1	39.4	0.880	0.350	1.651	0.0011	0.55
WNBC on Aux. Ant	0.20	181.40	0.0481	24.05	403.2	11.5	0.880	0.840	9.508	0.0105	5.25
WNYW on Main Ant	0.20	174.30	0.0462	23.10	516.1	39.4	0.840	0.450	2.486	0.0017	0.85
WNYW on Aux. Ant	0.20	202.60	0.0537	26.85	401.9	10.7	1.000	0.820	11.700	0.0130	6.50
WABC-TV on Main Ant	0.20	197.90	0.0525	26.25	468.7	31.9	1.000[2]	0.500[2]	16.150	0.0132	6.60
WABC-TV on Aux. Ant	0.20	360.50	0.0956	47.80	395.6	5.4	0.980	1.000	62.012	0.0713	35.65
WWOR-TV on Main Ant	0.20	202.60	0.0537	26.85	483.4	34.5	1.000[2]	0.500[2]	15.425	0.0119	5.95
WWOR-TV on Aux. Ant	0.20	419.40	0.1112	55.60	393.0	0.9	0.900	1.000	44.145	0.0514	25.70
WPIX on Main Ant	0.20	141.30	0.0375	18.75	499.6	37.1	0.800	0.200[2]	1.580	0.0011	0.55
WPIX on Aux. Ant	0.20	393.40	0.1044	52.20	394.4	3.8	0.980	1.000	56.568	0.0654	32.70
WNET on Main Ant	0.20	183.70	0.0487	24.35	483.4	34.5	1.000[2]	0.500[2]	15.075	0.0116	5.80
WNET on Aux. Ant	0.20	252.10	0.0669	33.45	393.9	2.9	0.950	1.000	43.230	0.0501	25.05
WPXN-TV on Main Ant	0.38	221.40	0.0587	15.45	443.3	26.3	0.800	0.150[2]	40.608	0.0371	9.76
WNJU on Main Ant	0.45	230.90	0.0612	13.60	421.3	19.7	1.000[2]	0.150[2]	102.825	0.1041	23.13
W60AI on Main Ant	0.50	190.80	0.0506	10.12							
WTC FM's on Master Ant	0.20	270.90	0.0719	35.95	394.8	4.1	0.820	1.000[2]	27.071	0.0625	31.25

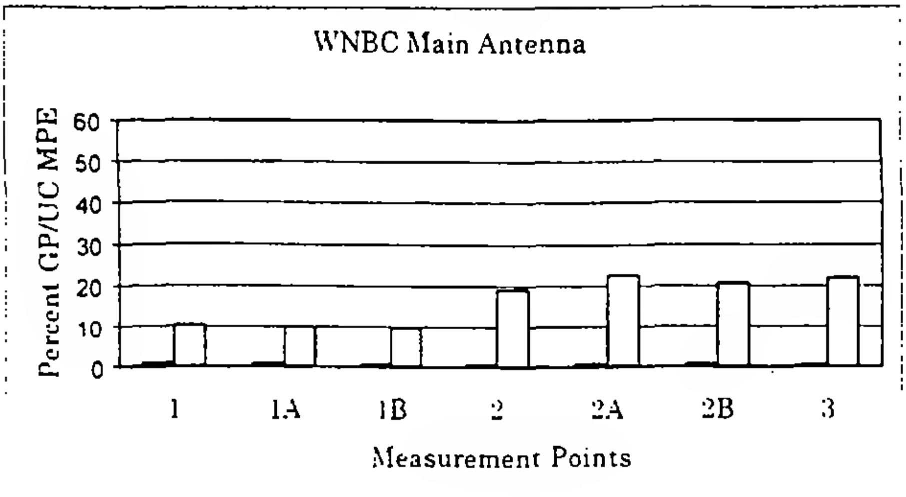
[1] Calculation of ERP based on manufacturer's horizontal and vertical plane pattern data unless otherwise noted

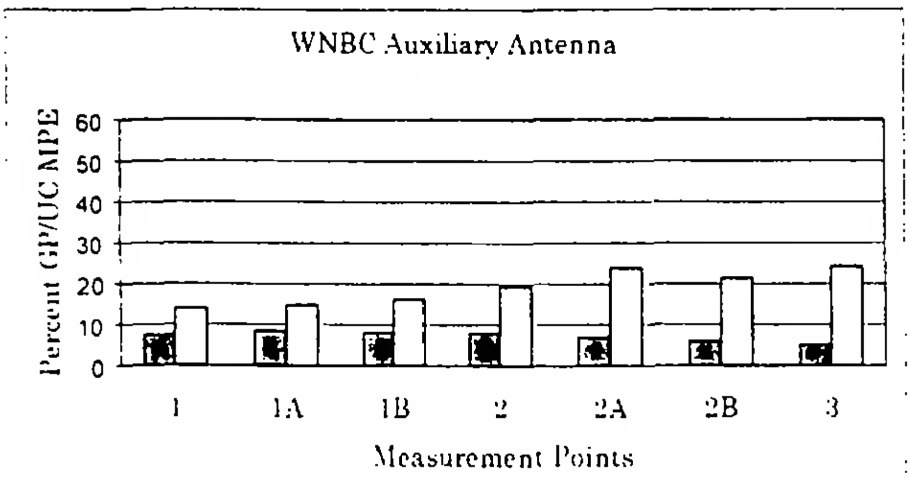
[2] Assumed value

**ENGINEERING REPORT
ELECTROMAGNETIC FIELD STRENGTH SURVEY
AT THE SOUTH TOWER OF THE
WORLD TRADE CENTER**

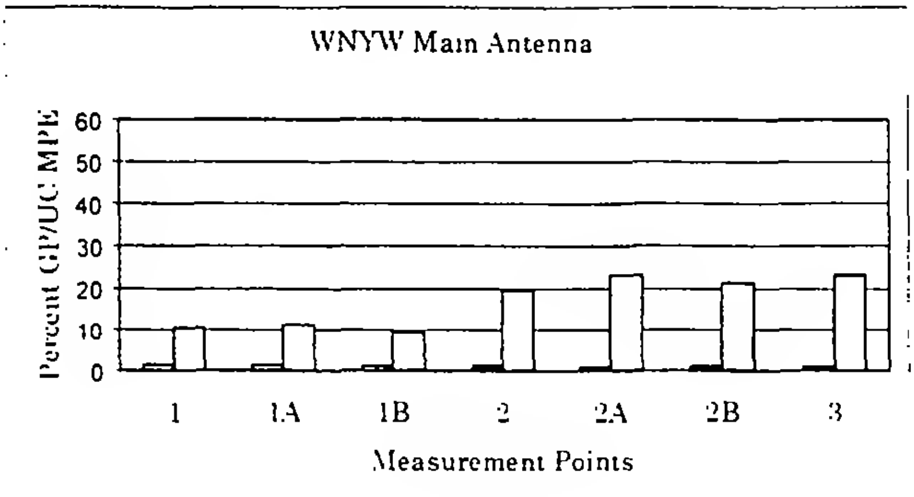
GRAPHICAL COMPARISON OF MEASURED AND
CALCULATED EXPOSURE LEVELS

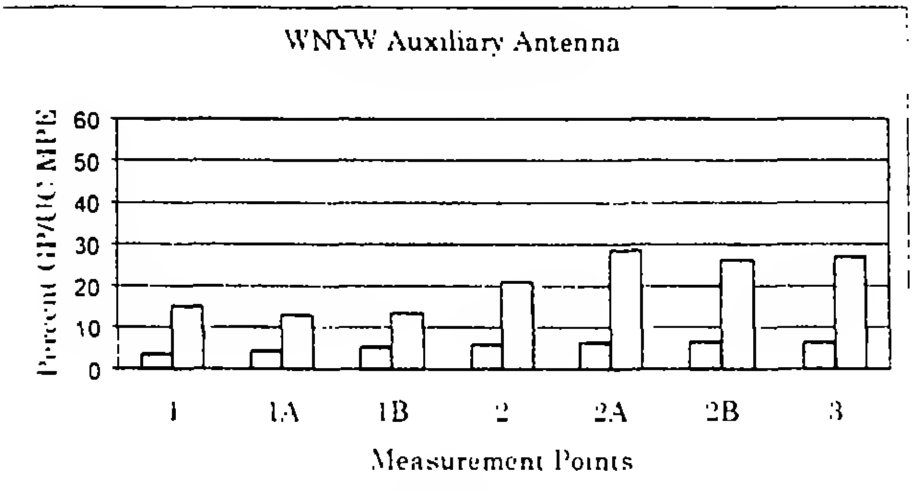


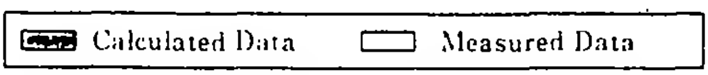


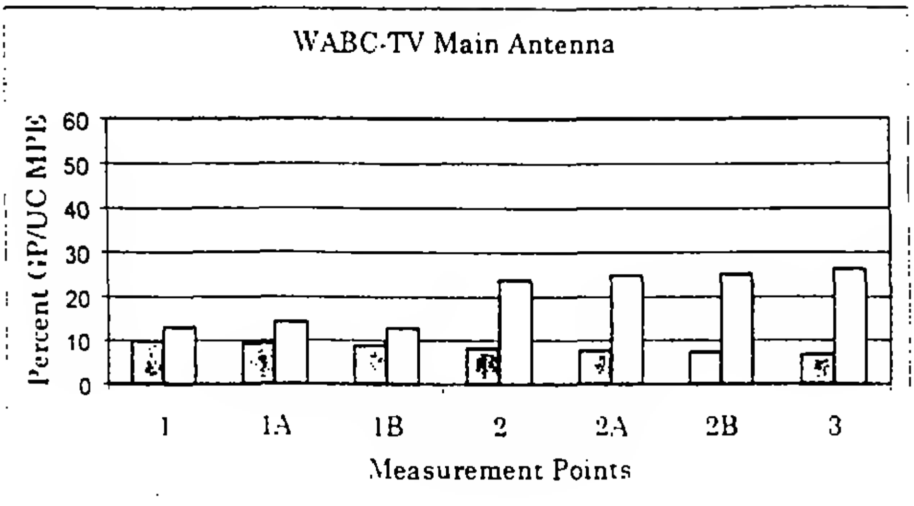


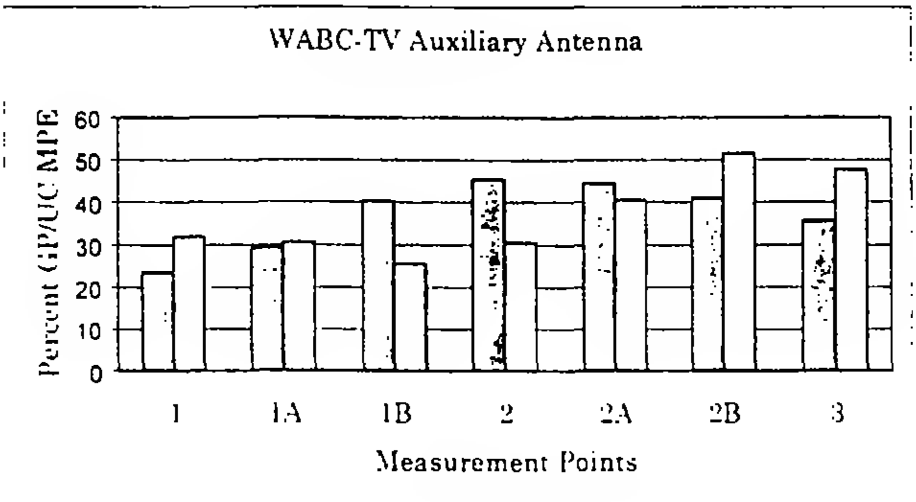
Calculated Data   Measured Data

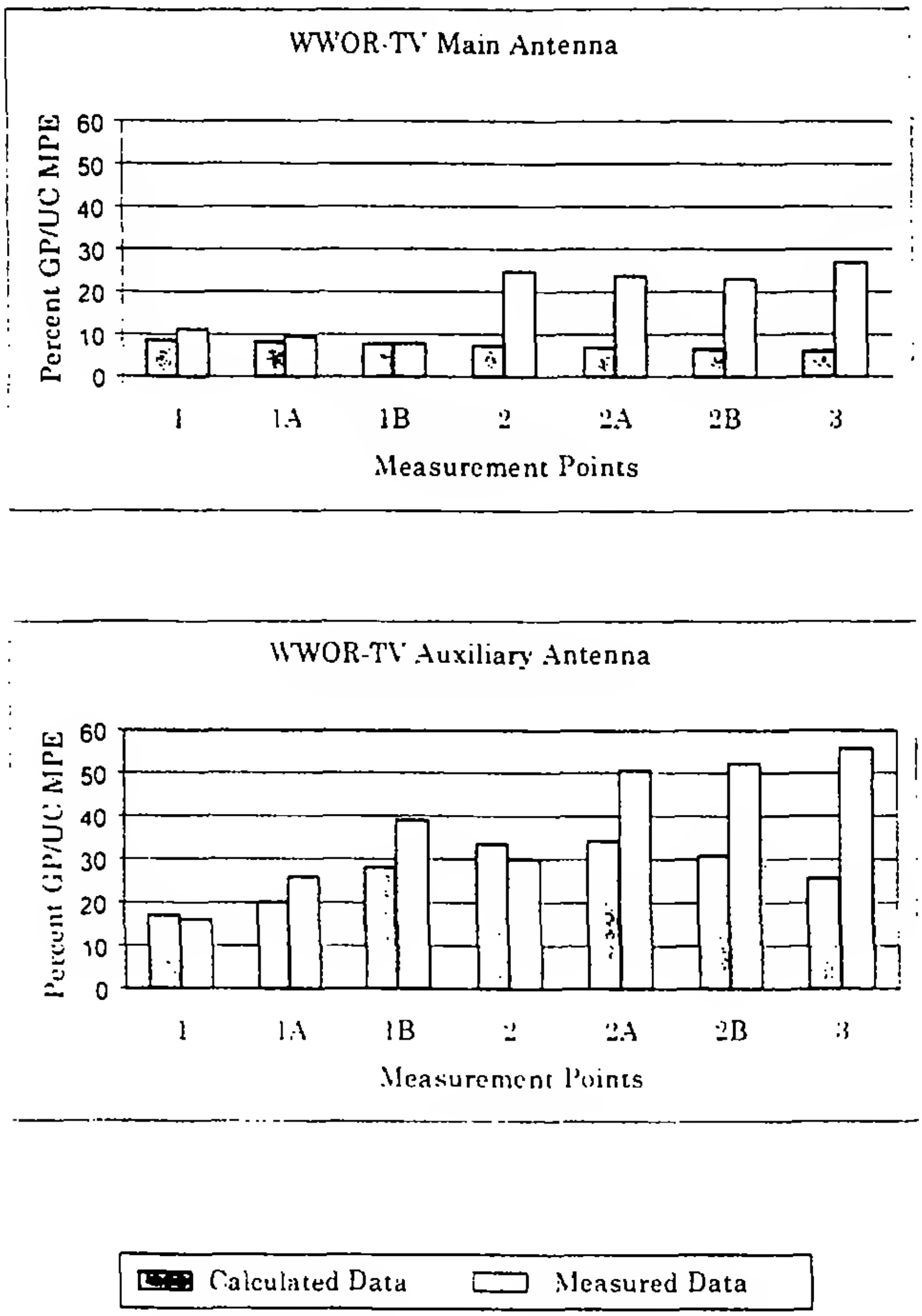

WNYW Main Antenna
Percent GP/UC MPE
60
50
40
30
20
10
0
1
1A
1B
2
2A
2B
3
Measurement Points

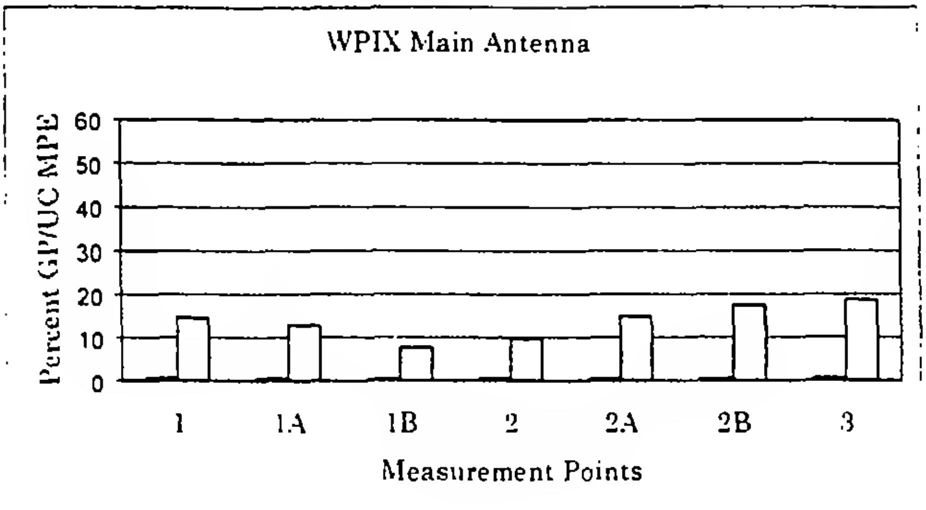

WNYW Auxiliary Antenna
Percent GP/UC MPE
60
50
40
30
20
10
0
1
1A
1B
2
2A
2B
3
Measurement Points

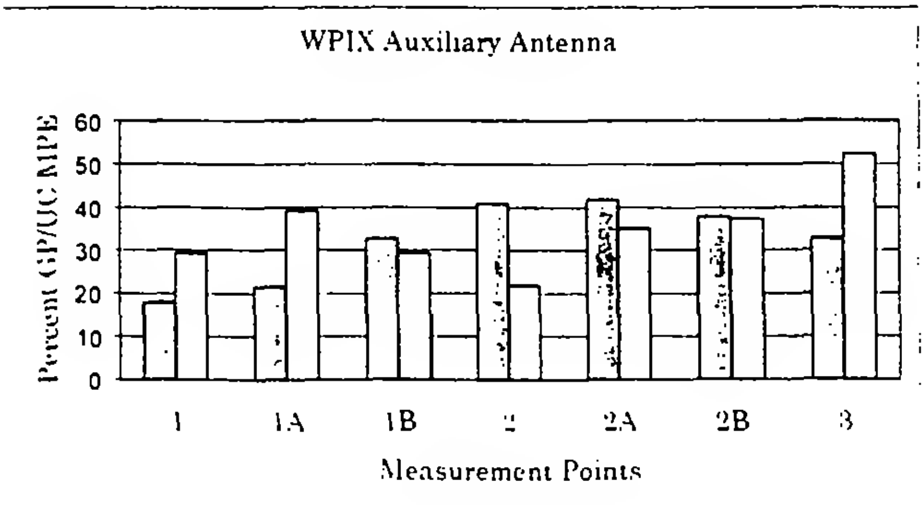

Calculated Data
Measured Data

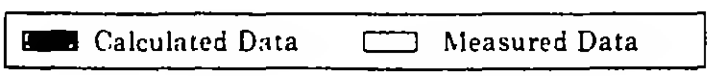

WABC-TV Main Antenna
Percent GP/UC MPE
60
50
40
30
20
10
0
1
1A
1B
2
2A
2B
3
Measurement Points

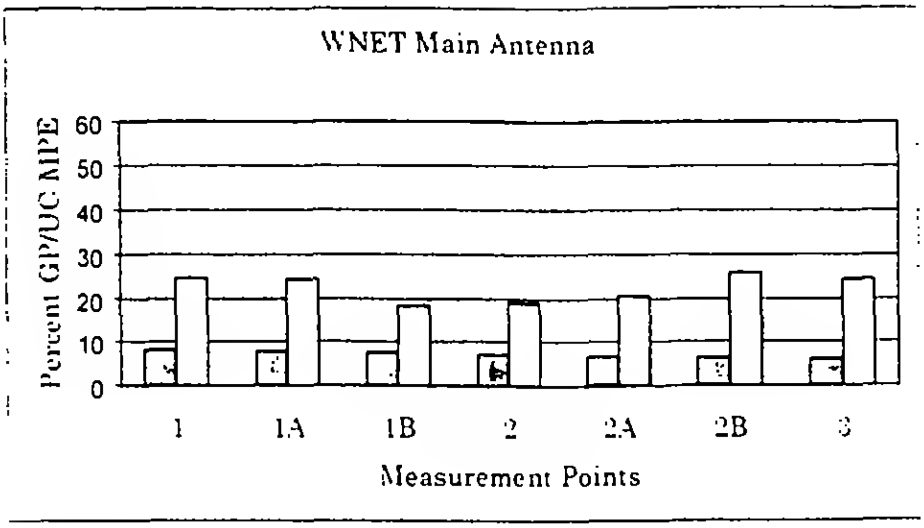

WABC-TV Auxiliary Antenna
Percent GP/UC MPE
60
50
40
30
20
10
0
1
1A
1B
2
2A
2B
3
Measurement Points
Calculated Data
Measured Data

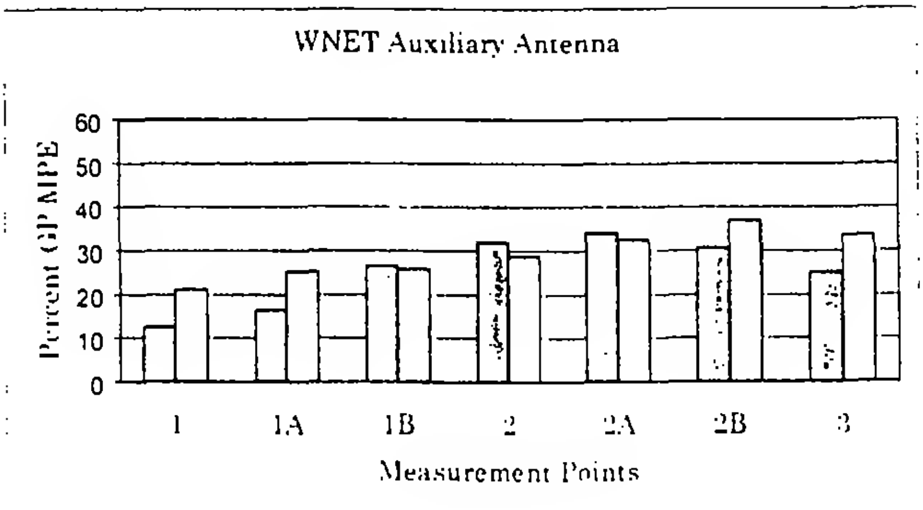

WWOR-TV Main Antenna
Percent GP/UC MPE
60
50
40
30
20
10
0
1
1A
1B
2
2A
2B
3
Measurement Points
WWOR-TV Auxiliary Antenna
Percent GP/UC MPE
60
50
40
30
20
10
0
1
1A
1B
2
2A
2B
3
Measurement Points
Calculated Data
Measured Data


WPIX Main Antenna
Percent GP/UC MPE
60
50
40
30
20
10
0
1
1A
1B
2
2A
2B
3
Measurement Points

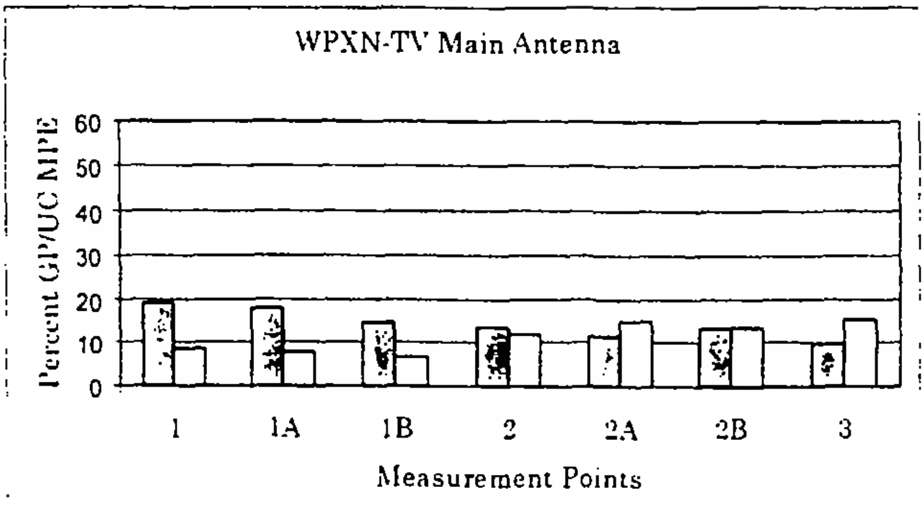

WPIX Auxiliary Antenna
Percent GP/UC MPE
60
50
40
30
20
10
0
1
1A
1B
2
2A
2B
3
Measurement Points

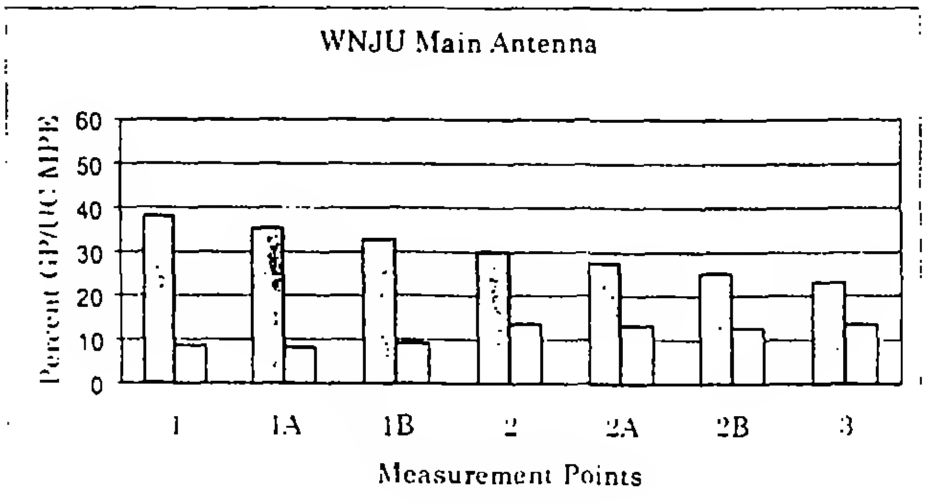

Calculated Data
Measured Data



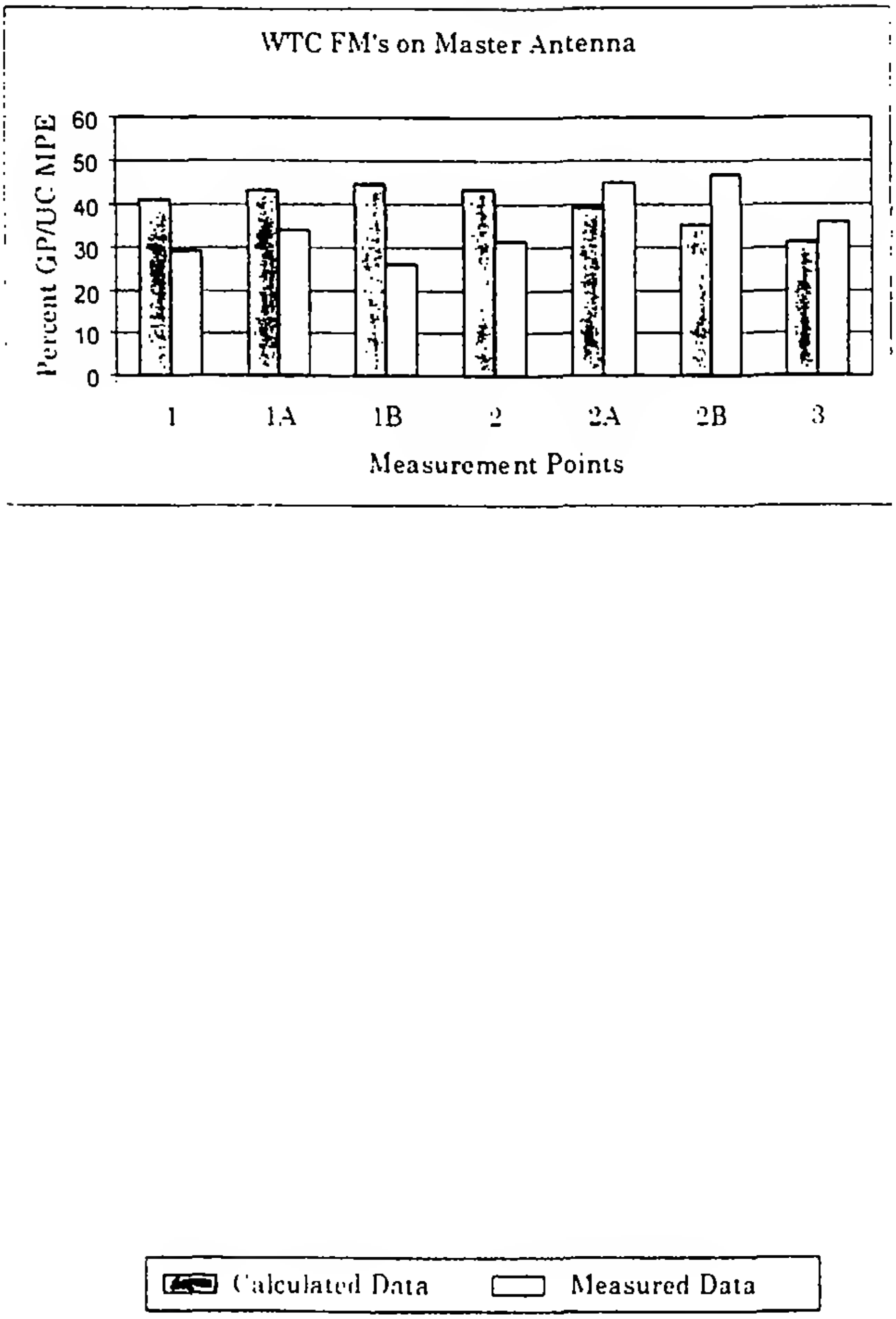


Calculated Data   Measured Data





Calculated Data   Measured Data


WTC FM's on Master Antenna
Percent GP/UC MPE
60
50
40
30
20
10
0
1
1A
1B
2
2A
2B
3
Measurement Points
Calculated Data
Measured Data

APPENDIX A-4

U.S. Federal Communications Commission
Antenna Structure Registration

UNITED STATES OF AMERICA
FEDERAL COMMUNICATIONS COMMISSION
ANTENNA STRUCTURE REGISTRATION

Part 17 of the FCC rules requires you to: (1) immediately provide a copy of this registration to each FCC licensed tenant of your structure (although not required, you may want to use Certified Mail to obtain proof of receipt); and, (2) display the Registration Number in a conspicuous place visible near the base of the structure (unless a government entity objects, in writing, to the display near a historic landmark). SEE INFORMATION ON REVERSE.

DUPLICATE 10/23/98

Owner: PORT AUTHORITY OF NEW YORK & NEW JERSEY CHARLES CLINTON 241 ERIE ST RM 300 JERSEY CITY NJ 07310-1397	Registration Number: 1002506 Issue Date: 03/23/98
Location of Antenna Structure: 1 WTC NEW YORK NY	Ground Elevation: 3.6 meters Overall Height Above Ground (AGL): 527.3 meters
Latitude: N40-42-43 Longitude: W074-00-49 NAD 27	Overall Height Above Mean Sea Level (AMSL): 530.8 meters

Painting and Lighting Requirements:
Paint and Light in Accordance with FAA Circular Number 70/7460-1J
…pters 3, 4, 5, 13
…al Conditions:

.0/26/98 U 20 D

FCC 854R
March 1996

JOSEPH R. LOFMO & ASSOCIATES
RECEIVED
OCT 29 1998
CONSULTING ENGINEERS

THE PORT AUTHORITY OF NEW YORK & NEW JERSEY MEMORANDUM

TO: George Tabeek, Project Manager
FROM: Paul W. Mitchell
DATE: March 11, 1998
SUBJECT: **RADIATION SAFETY SURVEY OF WORLD TRADE DEPARTMENT ION MOBILITY SPECTROMETER INSTRUMENT - ONE WORLD TRADE CENTER**

COPY TO: N. Chanfrau, M. Plaskon, P. ~~Taylor~~

On December 16, 1997, staff of Risk Management's Environmental and Occupational Health Division conducted a Radiation Safety Survey of the Ion Mobility Spectrometer which is stored in the lobby of 1 WTC. The survey consisted of an inspection of the storage area, leak test sampling of the sealed source unit, and an evaluation of current procedures and practices followed by personnel using the instrument. As you will see on the attached report no deficiencies were identified during the survey.

During the survey, sampling for radiation leakage of the sealed source unit using the swipe sample method was performed. The sample was forwarded to Monitoring Services for analysis and the result was found to be acceptable. A copy of the report is attached.

The next radiation safety survey is scheduled for June, 1998.

If you require further information regarding this survey, or if you have any questions, please call me at (201) 216-2173.

Paul W. Mitchell

Paul W. Mitchell, CIH
Manager
Environmental and Occupational Health Division
Risk Management

Attachments

World Trade Department Radioactive Source Survey

[illegible]	[illegible]	INSTRUCTION MANUAL AVAILABLE	RADIATION EMERGENCY OPERATING PROCEDURES MANUAL AVAILABLE	UNIT STORED IN SEPARATE LOCKED AREA
Barringer Ion Mobility Spectrometer, Model No. 400 (Serial No. 400-10A)	Acceptable	Yes	Yes	Yes

Monitoring Services

PO BOX 80044 • HOUSTON, TEXAS 77280-0044 • AREA CODE 713/841-0281 • FAX 713/841-4153

SEALED SOURCE LEAK TEST CERTIFICATE

PORT AUTHORITY OF NY & NJ
241 ERIE STREET ROOM 306
JERSY CITY ,NJ 07310
ATTN OF: WILLIAM POCKELS

C FILE 2194

S FILE 29436

N FILE 1662

INVOICE NO ______ DATE ______

RADIONUCLIDE NI-63

ACTIVITY 15 MCI CI SERIAL NO. 10A

WIPE DATE 121697 WIPED BY ______

EFF. .652

GROSS CPM 25 BKG CPM 22 NET CPM 3

$$\frac{\text{NET CPM}}{\text{EFF} \times 2.22 \times 10^6 \text{ DPM}/\mu\text{ CI}} = \text{MICROCURIE}$$

THE ABOVE SOURCE WIPE TEST HAS BEEN ASSAYED IN ACCORDANCE WITH OUR RADIOACTIVE MATERIAL LICENSE AND THE APPROPRIATE REGULATORY REQUIREMENTS. THE REGULATIONS DEFINE A LEAKING SOURCE AS ONE FROM WHICH AN APPROPRIATE WIPE TEST HAS REMOVED 0.005 MICROCURIE OR MORE OF ACTIVITY.

THE REMOVABLE ACTIVITY WAS 2.07E-06 MICROCURIE

ASSAY NO. 010798 43 DATE 01-07-19.98

ASSAYED BY [signature]

APPENDIX A-5

Memorandum March 11, 1998
Regarding Radiation Safety Survey, One WTC

THE PORT AUTHORITY OF NEW YORK & NEW JERSEY **MEMORANDUM**

TO: George Tabeek, Project Manager
FROM: Paul W. Mitchell
DATE: March 11, 1998
SUBJECT: **RADIATION SAFETY SURVEY OF WORLD TRADE DEPARTMENT ION MOBILITY SPECTROMETER INSTRUMENT - ONE WORLD TRADE CENTER**

COPY TO: N. Chanfrau, M. Plaskon, P. Taylor

On December 16, 1997, staff of Risk Management's Environmental and Occupational Health Division conducted a Radiation Safety Survey of the Ion Mobility Spectrometer which is stored in the lobby of 1 WTC. The survey consisted of an inspection of the storage area, leak test sampling of the sealed source unit, and an evaluation of current procedures and practices followed by personnel using the instrument. As you will see on the attached report no deficiencies were identified during the survey.

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Paul W. Mitchell

Paul W. Mitchell, CIH
Manager
Environmental and Occupational Health Division
Risk Management

Attachments

World Trade Department Radioactive Source Survey

[illegible]	[illegible]	INSTRUCTION MANUAL AVAILABLE	RADIATION EMERGENCY OPERATING PROCEDURES MANUAL AVAILABLE	UNIT STORED IN SEPARATE LOCKED AREA
Barringer Ion Mobility Spectrometer, Model No. 400 (Serial No. 400-10A)	Acceptable	Yes	Yes	Yes

Monitoring Services

PO BOX [illegible] • HOUSTON, TEXAS [illegible] • AREA CODE [illegible] • FAX [illegible]

SEALED SOURCE LEAK TEST CERTIFICATE

PORT AUTHORITY OF NY & NJ
241 ERIE STREET ROOM 306
JERSY CITY ,NJ 07310
ATTN OF: WILLIAM POCKELS

C FILE 2194

S FILE 29436

N FILE 1662

INVOICE NO ____________ DATE ____________

RADIONUCLIDE NI-63

ACTIVITY 15 MCI CI SERIAL NO. 10A

WIPE DATE 121697 WIPED BY ____________

EFF. .652

GROSS CPM 25 BKG CPM 22 NET CPM 3

$$\frac{\text{NET CPM}}{\text{EFFX}2.22\text{X}10^6\ \text{DPM}/\mu\ \text{CI}} = \text{MICROCURIE}$$

THE ABOVE SOURCE WIPE TEST HAS BEEN ASSAYED IN ACCORDANCE WITH OUR RADIOACTIVE MATERIAL LICENSE AND THE APPROPRIATE REGULATORY REQUIREMENTS. THE REGULATIONS DEFINE A LEAKING SOURCE AS ONE FROM WHICH AN APPROPRIATE WIPE TEST HAS REMOVED 0.005 MICROCURIE OR MORE OF ACTIVITY.

THE REMOVABLE ACTIVITY WAS 2.07E-06 MICROCURIE

ASSAY NO. 010798 43 DATE 01-07-19.98

ASSAYED BY [signature]

APPENDIX A-6

Richard Tell Associates, Inc., September 29, 1997,
"An Evaluation of the Radiofrequency Environment
at the WTC North Tower."

RICHARD TELL ASSOCIATES, INC.

An Evaluation of the Radiofrequency Environment at the World Trade Center North Tower

CONFIDENTIAL DOCUMENT

September 29, 1997

Prepared for

Motorola
U.S. Network Services Division

by

Richard A. Tell
Richard Tell Associates, Inc.

An Evaluation of the Radiofrequency Environment at the World Trade Center North Tower

Table of Contents

Acknowledgments

This project involved a large number of individuals and it was through the concerted effort of these people that this project was able to be accomplished with a minimum of problems. The team effort of all of those involved is appreciated and acknowledged. Mr. James Baker, Director of Engineering at WABC TV and Chairman of the TV Broadcasters All Industry Committee, played an instrumental role in helping coordinate the assistance provided by the broadcast community at the World Trade Center. Jim arranged for various personnel associated with the many broadcast stations at the WTC to participate in a coordinated fashion, working as part of the five measurement teams that carried out the measurements during the study.

Mr. Jules Cohen, P.E., long-time consultant to the TV Broadcasters All Industry Committee, provided helpful review, consultation and recommendations about various aspects of the study. Jules' past experience in RF field measurements at the WTC provided an additional degree of competence in reviewing the initial measurement plans developed for this study.

Mr. James Ault, Internet Communications, provided on-site computer related support during the actual measurements and helped insure that the large amount of data being collected by the various teams made sense and properly represented the intended, many measurement locations on the roof top. Mr. Ault also was responsible for customized modifications to the RoofView™ software package used to display measured RF fields and analysis of fields from the many wireless telecommunications antennas on the roof.

The following individuals, listed alphabetically, are acknowledged for their participation during the project:

Jim Ault, Internet Communications
Jim Baker, WABC-TV
Rick Bishop, Motorola
Harold Borth, WNYW-TV
Paul Brenner, WPIX
Charles Burnham, WABC-TV
Jules Cohen, Denny Associates, Inc.
Rod Coppola, WNET
Bryan Corley, Motorola
Dominick DePalma, WNBC
Don DiFranco, WABC-TV
Frank Graybill, WNET
Robert Gross, WPIX
Kurt Hanson, WABC-TV
Robert Martinez, WNBC-TV
Norman Michielini, WNYW
Dennis Mills, Motorola
Charles Mouzakis, MOCOMCO, Inc.
John Neuhaus, WWOR-TV
Rich Paleski, WNYW
William Steckman, WNBC-TV
Stephen Tell, Richard Tell Associates, Inc.
Al Yerger, Motorola
Ed Zaccardi, Motorola

An Evaluation of the Radiofrequency Environment at the World Trade Center North Tower

Summary

During June 6-9, 1997, a comprehensive survey of radiofrequency (RF) fields was accomplished on the north tower of the World Trade Center (WTC) to evaluate the magnitude and distribution of RF fields resulting from the many broadcast and wireless telecommunications transmitting facilities located at the WTC. A total of nine television (TV) stations and four FM radio broadcast stations operate from the WTC antenna facility on the north tower. In addition, some 83 wireless telecommunications antennas are located on the roof of the WTC for paging and specialized mobile radio services. Recent action by the Federal Communications Commission (FCC) to adopt new, more stringent rules related to Maximum Permissible Exposure (MPE) limits for RF fields has heightened interest by most FCC licensees in re-evaluating their facilities for compliance with the new rules which are proposed to become effective later in 1997. In light of the new federal regulations, and because of the large number of wireless telecommunications antennas located at a major broadcast transmitter site, it was deemed necessary to perform an in-depth evaluation of the existing RF environment at the WTC.

The study was designed to incorporate both direct measurements of the ambient broadcast fields and theoretical analysis of fields that could be produced by the many wireless telecommunications antennas. Theoretical modeling of wireless antenna fields permitted an evaluation that included the maximum possible RF field levels that might exist on the WTC roof since direct measurements of the wireless communications fields are fraught with uncertainty associated with their intermittent activity.

Coordination for the study was accomplished by interaction between Motorola, the broadcast community at the WTC represented by Mr. Jim Baker, Chairman of the TV Broadcasters All Industry Committee, and Mr. Jules Cohen, P.E., consultant to the All Industry Committee. Arrangements were made by Motorola to shut down operation of all of the roof-mounted wireless communications antennas except for 17 antennas used as 72 MHz paging links. The transmitters used with these paging link systems were, however, arranged to be operating continuously during the entire roof survey period to avoid variability in measured field values due to intermittent operation. Measurements were performed for three different conditions: (1) normal broadcasting operations, (2) the tower maintenance mode of operation normally used when access to the antenna mast on the roof is required from time-to-time and (3) an emergency, backup mode of operation, in which all stations operated in such a manner with auxiliary antennas that the maximum possible RF field levels would be found on the roof. While the emergency, backup mode of operation was acknowledged as an extremely rare and very unlikely scenario, it was included in this study for reference purposes and in the interest of completeness.

Field measurements were performed using broadband, isotropic field probes designed to provide an output that is weighted according to the frequency variation of the FCC rules for human exposure. By making use of a built in capability of the digital meters used with the probes, direct measures of the spatially averaged RF field levels, obtained over a height ranging from the roof surface to six feet above the roof, were possible, thereby allowing direct comparison with the FCC limits. An initial evaluation period in the afternoon of June 6 was followed by two nights of detailed measurements on the roof during June 7 and 8. Measurements at night were necessary to accommodate the concerns of the many wireless communications companies about disruption of service during periods of maximum message traffic.

While five measurement teams, consisting of Motorola and broadcast facilities personnel, collected data under the three defined conditions above, measurement data were entered into a software package designed for computing RF fields produced by wireless communications antennas. The program was modified to allow for display of the data in the form of colorized roof maps that portrayed the distribution and intensity of the measured fields. Subsequently, detailed analysis of RF fields that would be expected from the wireless antennas was performed to obtain estimates of the composite RF fields that would result with all antennas active. These results are summarized in Table 8 and show the maximum percentage of the MPE determined on the roof for each condition evaluated and the percentage of the roof area subject to fields less than 20% of the controlled exposure MPE, in the range of 21-50% of the MPE, 51-100% of the MPE and greater than 100% of the MPE. Several alternative scenarios were evaluated through the use of the RF analysis software including the effect of activating all of the present wireless antennas and raising the antenna mounting heights.

As can be seen from Table 8, the maximum RF fields expected on the north tower WTC roof range from about 57% of the controlled exposure MPE to 373% of the MPE, depending on the operational scenario. The contribution by the broadcast stations was found to be nominally 57% to 135% of the MPE without any contribution from the wireless antennas, although under normal broadcast conditions, no areas were found that exceeded the MPE for controlled exposures. Strong fields in the close vicinity of many of the wireless communications antennas mounted close to the roof surface are responsible for increasing the likelihood that the composite fields on the roof might exceed the FCC limits.

Based on the results of this study, it is clearly apparent that RF fields on the WTC north tower roof exceed the more stringent general public, or uncontrolled exposure, MPE contained in the new FCC rules, even under the best of the several scenarios studied. Under the combined action of both the broadcast stations and the wireless communications facilities, it is expected that RF fields will also exceed the more permissive controlled exposure MPEs set for workers with up to 27% of the roof being subject to such fields for the emergency backup condition. These results demonstrate that the roof should be designated as a controlled exposure area and that appropriate signage be installed at the site to inform individuals accessing the roof of the presence of strong

RF fields that could exceed general public, and worker limits, in some cases. It is my opinion that without the installation of appropriate signs, the roof area cannot be declared as complying with the new FCC rules for RF exposures. The present situation of no signage relative to RF fields must be corrected.

Beyond posting of the site, the development and implementation of an RF safety program should be considered for workers who have access to the roof. The safety program should contain site specific procedures related to work on the roof to insure compliance with the FCC rules. For example, areas that should be avoided could be identified on the roof and declared in the written program materials that would be provided to roof workers. All individuals who have access to the roof should be required to be presented with the RF safety program materials so that there is no question about them being informed of the presence of RF fields on the roof and appropriate procedures for reducing their exposure to help maintain compliance with FCC rules at the site.

Alternative methods for complying with the FCC rules include engineering changes such as increasing the mounting elevation of the wireless communications antennas and the use of RF protective clothing. The relatively dramatic effect of raising antennas on the composite RF fields on the roof is seen in Table 8 and associated roof maps in this report. In lieu of engineering modifications, the roof could represent an excellent site for the use of protective garments for controlling worker exposure.

Background

All FCC licensees are required to comply with rules related to Maximum Permissible Exposure (MPE) to RF fields. This requirement has existed since January of 1986, when the FCC first adopted RF exposure rules. In August of 1996, the FCC once again adopted updated rules on RF exposures that were more stringent than those previously used. These new rules, in contrast to the earlier ones, placed new requirements on most of the wireless telecommunications industry by requiring engineering evaluations of transmitting systems meeting certain criteria such as effective radiated power and antenna mounting height. After October 15, 1997, affected licensees will be required to evaluate and bring their antenna sites into compliance with the new rules. Motorola, in its role as site manager for telecommunications (non-broadcast) facilities at the north tower at the WTC, is presently responsible for the operation of 83 antennas located on or near the roof level of the north tower. These antennas, in some cases, have the potential for producing strong RF fields in their vicinity and, hence, particular care must be used during work activities near the antennas to insure compliance with the applicable MPE limits imposed by the FCC. The RF fields produced by the telecommunications antennas are additive, of course, and, hence, any ambient RF fields produced by the broadcasting facilities on the WTC north tower will increase the background level of RF energy to which personnel working on the roof may be exposed. Motorola is committed to evaluating the roof RF environment in sufficient detail to permit an accurate assessment of compliance with the FCC rules and to implement any necessary engineering, work practices or personal

protective equipment (PPE) controls to insure compliance. It is in this context that the subject study was performed.

A number of past studies performed at the WTC have investigated the magnitude of RF fields on the north tower roof. However, in the interest of creating a relatively high resolution map of ambient RF fields, and to insure that sufficient data were obtained on the RF fields associated with the many wireless antennas, the study documented here was performed.

Introduction and Study Objectives

This report documents the design, execution, results and conclusions of a major study of RF fields atop the roof of the north tower of the WTC. Several objectives of the study were envisioned:

Because of the high concentration of RF transmitting facilities located at the WTC, it has been of interest to Motorola to perform a current assessment of the existing RF field environment from the perspective of evaluating compliance with applicable rules on RF exposure adopted by the Federal Communications Commission (FCC). One objective of this study was, then, to perform a detailed survey of the existing RF fields produced by the broadcast facilities at the WTC so that additional work to assess RF fields produced by the many telecommunications antennas could be put in perspective relative to FCC rules.

A second objective was to analyze the RF fields that would be associated with full-time operation of the telecommunications antennas, exclusive of the contribution to RF fields from the broadcast facilities as well as in combination with the broadcast fields. Again, the results would be scrutinized from the point of view of compliance with FCC RF rules.

A third objective was to examine the results of the measurements and analyses to identify practical engineering approaches to mitigating excessive RF fields, if they should exist, and appropriate site specific work practices for minimizing personnel exposure.

This study was not directed to the issue of RF fields that exist on the structure of the antenna mast or inside the mast. The outer surface of the antenna mast can be accessed by various platforms and ladders near the bottom of the mast. At the upper level of the climbing structure, personnel can come into very close proxmity of some of the auxiliary antennas mounted on the mast. While the exposure that individuals might encounter when working on this structure during tower maintenance mode was not evaluated in this study, care should be used in examining this area to avoid RF exposure in excess of the standard.

Description of the World Trade Center Transmitting Facilities

The north WTC tower is home to nine TV stations and four FM radio stations. Antennas are supported by a central antenna support structure that extends 351.5 feet above the roof. Figure 1 illustrates the configuration of the antenna mast showing the location of the main antennas as well as various auxiliary antennas that are used during tower work or as emergency backup antennas during temporary failures associated with the main antennas for some stations. Table 1 lists the various stations and indicates their licensed effective radiated power (ERP) levels and the approximate height of each antenna to the center of radiation above the roof. These broadcast stations normally operate 24 hours per day, seven days per week, except for maintenance periods when personnel must access the antenna mast, for example to replace beacon lamps. During those periods, WCBS (channel 2) normally switches to transmission from its auxiliary antenna located at the Empire State Building, the UHF TV stations cease operation and the remaining VHF TV stations assume operation from their lower mounted auxiliary antennas. Because of the lower mounting height of the auxiliary antennas, elevated RF fields at roof level will be expected.

Some 83 wireless telecommunications antennas are also situated on the roof of the north WTC tower. These facilities, typically consisting of vertical, collinear type antennas, usually omnidirectional in their radiation characteristics, are scattered over most of the roof area. In some cases, the antennas are mounted very close to the roof surface while with others the bottom of the radiating aperture of the antenna is at least eight feet above the roof deck. While none of these antennas operate with power levels comparable to any of the broadcast antennas, their close proximity to the roof surface and the fact that the area near the antennas is unrestricted in terms of access lead to the possibility that these antennas can also play a significant role in RF exposure of roof workers who may have reason be near them. Figure 2 shows an example of the disposition of various telecommunications antennas on the roof.

Technical Approach to Study

A two-pronged approach was taken to investigating the RF environment at the WTC. First, because of the intermittent nature of the various telecommunications transmissions, it was reasoned that attempting to measure these RF fields would be problematic. Without continuous operation of the stations, it would be difficult to confirm that field measurements made at any given point on the roof and at any given time would reflect the maximum possible RF field levels that might be achievable under maximum operating conditions. Hence, it was decided that a more appropriate way to assess the telecommunications fields would be via theoretical analysis. In this way, the maximum possible output from each antenna could be assessed. This would require, of course, detailed information on the precise location of each antenna, their physical sizes (radiating aperture heights), antenna input power levels, frequencies and mounting heights. This information was readily available from Motorola who manages the wireless telecommunications aspects of the WTC antenna site.

Secondly, direct measurements were proposed as the most expedient and accurate method for assessing the contribution of the broadcast transmitting facilities to the aggregate roof-top fields. Such measurements would, however, require that any contribution made by the many wireless telecommunications service antennas be controlled and, preferably, eliminated. Arrangements were made by Motorola to shut down the operation of all telecommunications antennas on the roof, during the field measurement exercise, except for several antennas used as paging links to important paging services. These antennas represented 72 MHz paging links and arrangements were made to insure that each of these transmitters were locked on during the measurement periods. In this fashion, while these 17 antennas would introduce some contribution to the ambient RF fields, their contribution would be constant with time without the attendant problems of dealing with intermittent sources as discussed above.

The measurement plan was for shutting down the remaining telecommunications antennas beginning at 10:00 p.m. for as long as the measurements took to accomplish. To facilitate obtaining the required data in the shortest reasonable time, arrangements were made to field five measurement teams. In this way, the entire roof area, consisting of approximately 900 measurement points, could be measured in about a 90 minute period of time. Immediately following a measurement period, the telecommunications facilities were activated to minimize their down-time.

During an early planning meeting between Motorola and the WTC broadcast community, it was decided that such a study should examine three alternative modes of operation of the WTC broadcast stations: the normal operating mode with all stations operating from their main antennas, the tower maintenance mode of operation, as described above and a worst case (emergency backup) mode of operation in which the VHF TV stations would switch to their lower auxiliary antennas, WCBS (channel 2) would remain operating from its main antenna rather than switching to its auxiliary antenna at the Empire State Building, the UHF stations would remain operating, and WQCD-FM would operate into the master antenna at the WTC (normally, WQCD-FM operates from the Empire State Building). Although the tower maintenance mode of operation is the most likely scenario for operation other than the normal mode, it was felt that the absolute worst case possibility of strong RF fields on the roof should be investigated. The results of such a measurement would reveal the greatest possible RF fields that could occur with the present stations and provided a degree of completeness to the study.

A test-run was scheduled during the afternoon of June 6, to familiarize individuals participating during the measurements with the roof and to practice the special measurement procedures that would be used during the evening tests. During that afternoon, the measurement teams were assembled and lead through a series of evaluation measurements to assess measurement repeatability and inherent artifacts introduced by reflections from the presence of the observer. Each measurement team consisted of three individuals, a person performing the measurement, one for recording the resulting data and

another person to assist in identifying the many measurement points assigned to the various teams. The presence of the third team member was extremely valuable since all of the test measurements were performed at night with very limited lighting on the roof; spotting each sequential measurement point at many areas of the roof was challenging and to maintain a consistent rate of covering all the required measurement points required minimal time spent making sure of a particular point. Motorola provided the individuals for performing the measurements, since these personnel had past experience with the equipment and the techniques, and the WTC broadcast community provided personnel to fill out each measurement team.

The actual test measurements were performed during late Saturday night, beginning about 10:00 p.m. and early Sunday morning, beginning about 2:00 a.m., during which time both the normal and emergency, worst-case backup modes of operation were studied. During early Monday morning, the tower maintenance mode of operation was tested. Due to a temporary problem with operation of a coaxial switch at WNET (channel 13), the early Monday morning test protocol had to be delayed to approximately 4:00 a.m. whereupon the measurements started and were completed by approximately 5:30 a.m.

Processing of the measurement data included analysis of the projected RF fields that are produced by the 72 MHz paging link transmitters that were active during the measurements. In this way, the contribution of the paging links could be removed from the measured ambient fields. By knowing the location of each 72 MHz antenna, the RF fields in the vicinity of each such antenna, computed on the basis of antenna input powers and other technical parameters, could be subtracted from the total field consisting of both the broadcast and paging link transmitters.

The theoretical analysis of RF fields from telecommunications antennas was accomplished with the use of the RoofView™ software package originally developed for application at roof-top antenna sites. RoofView is a sophisticated Microsoft Excel™ spreadsheet that performs a near-field computation of the RF fields associated with vertical collinear telecommunications antennas of the type commonly used on the WTC roof.[1] RoofView performs calculations of RF fields for every square foot of roof area defined by the user and expresses the computed fields as a percentage of a selected human exposure limit. Each roof pixel is then colored in accordance with user selected values for field thresholds and colors for the composite RF field from all selected antennas on the roof. This analytical tool was believed to be the best approach to analyzing the complex antenna configuration on the WTC roof top. Since RoofView allows for convenient solution of what-if scenarios for antenna locations and antenna mounting heights, it would permit easy examination of various alternatives for mitigating excessive RF field levels, should such be found during the study. A customized version of RoofView was developed specifically for application to the WTC project that permitted inputting of measurement values obtained on the roof and presentation of colorized roof maps showing

[1] RoofView™ is a development and product of Richard Tell Associates, Inc., Las Vegas, Nevada.

the distribution of the measured field values. Details of the software are given in the section below on RoofView RF Analysis Software.

Instrumentation and Measurement Methodology

RF fields were measured via the use of broadband, isotropic electric field probes (Narda Model 8742) connected to a digital survey meter (Narda Model 8718). The use of broadband instrumentation was considered the only viable alternative for accurately assessing the ambient RF fields in terms of spatially averaged values. Since the Maximum Permissible Exposure (MPE) limits in the FCC rules are specified in terms of spatially averaged values of the squares of the fields or plane wave equivalent power densities, no other method capable of measuring the individual contributions of the many different frequencies present on the WTC roof was deemed suitable for acquiring the massive amount of data needed for this study. For example, commonly applied narrow-band measurement methods, involving tuned receivers or spectrum analyzers connected to calibrated reception antennas, are simply not practical for performing spatially averaged values of electromagnetic fields. However, using broadband measurement probes permitted the direct assessment of the spatially averaged field magnitudes by slowly moving the probe along a vertical axis from the roof surface to a height of six feet. Using the Narda Model 8718 meter, readings were acquired at a rate of 10 per second from the probe during the measurement period. At the termination of this process, lasting between approximately 12 and 15 seconds for each measurement, the meter automatically presented the spatially averaged value of the readings taken at that point.

The Model 8742 probe has a shaped frequency response that is designed to match the frequency dependency of the new FCC MPEs over the frequency range of 300 kHz to 2,000 MHz. This shaped frequency response provides for measurements in complicated field environments, similar to the WTC antenna site, in which numerous RF fields, each at different frequencies over a wide range, are appropriately summed but weighted according to the exposure limits at each frequency. In this way, the readings on the Model 8718 meter are in terms of a percentage of the MPE, not the equivalent plane wave power density. Hence, through use of this probe and meter combination, the measurement task was considerably simplified and permitted all of the measurements to be made in a timely fashion. This would not have been possible using a flat response probe since the relative contribution of the many different frequency fields would not have been known and, therefore, it would have been impossible to determine whether a given power density reading was actually in compliance with the frequency dependent MPE. In practice, all measurements made during the project included recording the spatially averaged value and maximum value of the percentage of the measured MPE even though it was the spatially averaged value that was of most importance. Figure 3 shows the Narda Model 8742 probe and Model 8718 meter that were used during a measurement. The back lit screen of the meter was used to advantage during the night-time measurements allowing the field measurements to proceed without interruption.

The Model 8742 probe is specified to permit measurements over the range of 0.6% to 600% of the MPE for controlled or occupational exposures. The detection elements within the probe are compensated diodes that are used in the square law response range so that the readings are properly related to the sum of squares of the electric field components and, hence, will correctly represent the magnitude of the composite RF field from multiple frequency fields that are simultaneously present at the probe. The Model 8742 probe has a specified isotropic response of ±0.75 dB between 1.5 MHz and 2,700 MHz. This specification is related to the possible variation in reading due to orientation of the probe in the field being measured and corresponds to a maximum variation of +18.9% and -15.9% as the probe is rotated or reoriented within the field.

Each probe was individually calibrated by the manufacturer at 13 frequencies across its detection range of 300 kHz to 2,700 MHz with RF fields having an uncertainty not exceeding ±0.5 dB. Correction factors were determined for each of these frequencies such that, if measurements are being performed at a single frequency (not the case in the WTC study), these calibration data can be used to correct the meter reading for the response of the individual probe. Narda warrants that the frequency sensitivity of the Model 8742 probe will not exceed 2 dB from the standard for exposure.[2] Table 2 lists the manufacturer's determined correction factors for each of six Model 8742 probes that were available for use during the WTC project. Table 2, and Figure 4, show that each of the six probes conform to the specification of ±2 dB deviation from the standard, the greatest deviation being at the lowest calibration frequency of 300 kHz. The probe having serial number 1004, however, was observed to exhibit the greatest correction factors in what was presumed to be the most important frequency range of nominally 50 MHz to 1000 MHz when compared to the other five probes. Based on this observation, and in the interest of reducing unnecessary uncertainty in the survey results, it was decided that the roof measurements should be performed with the remaining five probes which exhibited a much tighter grouping of correction factors.

For the five probes used in the general RF survey, Table 3 summarizes the correction factors over the important frequency range for which data were available, that being 27 MHz to 915 MHz. The data were analyzed from the point of view of determining the overall average value by which the probes, as a group, might read low or high compared to the true field magnitude. The results indicate a possible overall average low reading of 21.6% (-1.06 dB) and a possible overall average high reading of 39.5% (1.44 dB). This analysis suggests that, on average, the probes used in the survey might under-estimate the true field by 21.6% (range of 16.7% - 30.0%).

Since a high resolution mapping of the roof RF fields was desired, a relatively fine five foot by five foot measurement grid was defined for the accessible roof area following

[2] While the Narda Model 8742 probe was designed to conform to the frequency dependency of the ANSI/IEEE C95.1-1992 standard for controlled environments over its entire frequency range of 300 kHz to 2,700 MHz, within ±2 dB, the manufacturer has determined that this probe also conforms, within the ±2 dB specification, to the recent FCC rules which adopted the recommendations of the National Council on Radiation Protection and Measurements (NCRP, 1986) for frequencies up to 2,000 MHz.

the general guidance on measurement procedures recommended by the National Council on Radiation Protection and Measurements (NCRP, 1993). The roof of the WTC, not including the window washer track along the outer perimeter of the roof, is a square approximately 173 feet on a side. Hence, a square consisting of 1,225 potential measurement points (35x35) was defined prior to the study (overall area of 170 by 170 feet equivalent to 28,900 ft^2). Measurement points were laid out by starting in the southwest corner of the roof and measuring in five foot increments relative to that corner of the roof using an x-y coordinate system. Three regions within the defined area used for the stairwell to reach the roof, the central broadcast antenna mast area and the window washing machine docking area could not be measured, reducing somewhat the actual area to be measured. These three areas amounted to 1,695 ft^2 making the valid measurement area a total of 27,205 ft^2.

The measurement plan called for excluding measurements in the very close vicinity (within 2.5 feet) of metallic structures including antennas, cable trays, lights or any other features that could materially perturb the local field strengths. This practice reduced the total number of roof-top measurement points from a potential of 1,225 down to 889. Figure 5 illustrates these 889 measurement points and shows the areas allocated to the stairwell, antenna mast and window washer unit.

During the night-time measurements, a single spatial scan was performed at each valid measurement point (i.e., those more than 2.5 feet from any antennas or metallic structures). The measurements were accomplished with the individual performing the measurements standing so that the arm holding the probe was perpendicular to a radial line from the measurement point to the central antenna mast. In this way (a) the body was never between the field probe and the antenna mast and (b) the probe was never between the mast and the body. This approach was taken to minimize both shielding and reflections that would interfere with measurement of the desired field values.

A total of 3,267 measurements were performed during the project which includes the initial evaluation measurements (600) (see Special Measurement Evaluation) as well as the area roof measurements during the two nights of the project (2,667).

Special Measurement Evaluation

Each of the five measurement teams was equipped with the same model meters and probes. Initially, during the afternoon evaluation phase of the project, these five meters were used by the respective teams to characterize the variability in the measurement process that was subsequently used at night. The measurement evaluation phase of the study consisted of having each measurement team measure the spatially averaged RF fields at a total of ten randomly selected points distributed across the roof that had been defined earlier. At each of the ten points, the individual performing the measurements faced the marked spot on the roof from each of four directions, 90 degrees with respect to one another, for each measurement. Once the four measurements of spatially averaged fields was completed, the team proceeded to another measurement point until the entire set of

ten points was completed. This same process was then repeated a total of three times such that each team performed 120 measurements at the ten points. Through this process, data were generated that revealed something about the repeatability of the measurement process. Variation among the four measures of field at a point are influenced by the perturbations that can be caused by the body of the observer. Such perturbations may include both shielding of the measurement point from some of the fields or reflections of fields from the body back to the measurement point.

Table 4 summarizes the observed variation in measured percentages of spatially averaged fields over all orientations and three repetitions for all ten measurement evaluation points on the WTC roof for each of the measurement teams. The results reported in Table 4 indicate that each measurement team demonstrated quite consistent technique since the range of deviation in the many measurements is quite small (9.9% to 14.4%) over all five teams with an average standard deviation in the measured values of 12.6%. This represented a positive deviation of +0.51 dB and a negative deviation of 0.59 dB. Thus, these data indicate that the measurement process itself was reasonably stable and within the inherent accuracy and uncertainties of the measurement probes.

RoofView RF Analysis Software

While the many measurements conducted at the WTC formed a substantial basis for this study, the theoretical analysis of RF fields was equally important since the contribution of the many wireless communications antennas to the overall aggregate field levels had to be determined as a part of the compliance evaluation objective. Fields produced by the wireless antennas were analyzed through the use of the RoofView™ software package which was designed specifically to address vertical collinear types of wireless communications antennas.[3] This program is a sophisticated Excel™ spreadsheet that can model the RF fields in the vicinity of multiple antennas located on a roof-top antenna site, using a near-field model, taking into account the frequency of each field source and producing colorized roof maps that express the composite fields from all selected antennas in terms of a percentage of a selected exposure limit <u>based on a spatial averaging of the fields</u>. In this sense, the output is directly comparable to the frequency shaped probes used in the measurement phase of this study and, hence, can be amalgamated with the measurement data. This feature strongly influenced the use of the RoofView software since it would allow for convenient summation of the ambient broadcast fields with projected fields from the various wireless antennas, allowing for a very fine-grain analysis in the near-vicinity of each antenna.

RoofView carries out calculations at every selected one-square-foot pixel of roof surface for every selected antenna contained in its underlying data table. Detailed information obtained from Motorola was entered in this data table which specified each antenna's exact location on the roof in x-y coordinates, the mounting height to the base of the radiating aperture from the roof surface, the aperture height (important for near-field

[3] RoofView™ is an analysis tool developed and marketed by Richard Tell Associates, Inc.

analysis), antenna input power levels, frequencies associated with each antenna, and pointing directions and azimuthal beamwidths for directional antennas. Human RF exposure limits may be selected from an array of 14 different standards and guidelines. Since the Narda broadband probes are designed to read out in terms of a percentage of the controlled environment MPE of the IEEE (300 kHz to 2,700 MHz) and the new FCC limits for controlled exposure (300 kHz to 2,000 MHz), all analyses accomplished with RoofView for this study were referenced to the FCC controlled exposure MPEs.[4]

User defined thresholds are used to control the way in which RoofView displays analysis results. In this case, four ranges corresponding to <20%, 20-50%, 50-100% and >100% of the FCC worker MPE were used to determine the thresholds and, hence, coloration of the roof maps that are generated in the computation process. These four thresholds were set to produce map colors of green, yellow, red and blue respectively. Hence, all pixels having composite fields in the range of 50 to 100% of the MPE were displayed as red and so forth. Using this approach, colorized roof maps were generated for the WTC roof that could provide meaningful graphic feedback on the magnitude and distribution of RF fields.

The RoofView software computes fields of vertical collinear antennas using a cylindrical model in which the radiated power from the antenna is assumed to be distributed over the surface of an imaginary cylinder that surrounds the aperture. Appendix A provides details of the use of this model in RoofView. A user set factor, in terms of the antenna aperture height, is entered to inform RoofView as to when it should begin using a far-field, inverse square law for power density as compared to the inverse distance law in the near field. For the analyses prepared in this study, a factor of 1.5 times the aperture height was applied; as the many calculations are being performed within RoofView, the program makes decisions 'on the fly' as to how it should compute the field at each specific pixel.

RoofView version 3.0 was modified specifically for this project to permit the inclusion of the measurement data so that it could be plotted in a fashion similar to how the computed model results are normally plotted and so that computed fields of the many wireless telecommunications antennas could be combined with the measurement data to assess the combination effects of both the ambient broadcast fields and wireless antenna fields. Also, by performing a reverse calculation of the fields associated with the 72 MHz paging link antennas, which were not turned off during the measurements, an estimate of the field produced by only the broadcasting facilities could be made.

Although the colorized roof maps represent a powerful visual approach to examining the combined effects of multiple antennas at a roof-top antenna site, the RoofView software also provides a statistical summary of the results that can be highly

[4] The FCC RF exposure limits specify a more stringent MPE for uncontrolled or public exposures that are one-fifth the MPEs for controlled or worker exposure limits. This means that fields measured or calculated to be 20% of the controlled (worker) MPE are equivalent to 100% of the uncontrolled (public) MPE.

informative of the extent of the roof area exhibiting RF fields within the various ranges selected by the user. For all of the measurement and analysis results reported here, the square footage and percentage of the roof area subject to fields in the four defined ranges (percentages of the FCC RF MPEs) were determined and are presented along with the corresponding roof maps.

While RoofView normally computes the estimated field at each roof pixel, each comprising a square foot of the roof, the field measurements were only obtained at a nominal spatial resolution of five feet. To allow the measurement data to be presented in a compatible manner, modifications were made to the software to perform an interpolation of the measurement data on the basis of a one-foot spacing using a straight line method of interpolation. Alternative, more sophisticated interpolation methods were initially evaluated for displaying the measurements but in the final analysis, it was decided that a straight line method was satisfactory considering the boundary conditions present at the WTC site.

This interpolation method was evaluated by collecting detailed field measurements of the spatially averaged fields in a five by ten foot grid located in the southwest part of the roof, near one corner of a helipad. A total of 66 measurement points, each one foot adjacent to the next point, covered the overall area including the points along each edge of the area. In this case a single spatial average scan with the probe was made at each point, following the same protocol used for the entire roof measurements. These particular measurements were accomplished at approximately midnight during the second evening of measurements with all broadcast stations operating in their normal mode on their main antennas.

Table 5 presents the individual measured values of spatially averaged fields expressed as a percentage of the MPE. These data indicate a general increase in field level toward the northern edge of the test area compared to the southern edge ranging from approximately 28% MPE to about 45% MPE. An evaluation of the interpolation scheme was performed by using only the measured values obtained on five foot centers. This represented a total of six measurement values from which all of the other values, at one foot intervals, were determined as shown in Table 6. The differences between the interpolated values and the corresponding actual measurement values were computed and are given Table 7 as percentages. These differences ranged from as much as 12.8% below a measured value to as much as 12.0% higher than the real value, the average difference being approximately +0.97% with the distribution of low and high values being very close to the same proportion. Of the 56 interpolated values, 28 were less than the measured value and 32 were greater indicating, in this test, that the interpolation scheme did not seem to introduce any significant bias in the resulting values.

RF Measurement and Analysis Results

The numerous results of both measurements and analyses at the WTC are presented in this section beginning with the normal operation scenario for broadcast facilities with the inclusion of the 72 MHz paging links and progressing through the tower maintenance mode of operation and ultimately to the worst case, backup scenario. For these various conditions, several alternative RF conditions were examined.

■ Normal Broadcasting Operation

Figure 6 shows the measurement results for normal broadcasting operation with the 72 MHz paging links included. In this case, it is apparent from the roof map that a substantial area of the roof, approximately 63%, exhibited RF field values less than the continuous exposure MPE for uncontrolled exposures, or for unaware public access. Conversely, about 37% of the roof area (about 17,000 square feet) had fields above the uncontrolled exposure MPE, corresponding to 20% of the controlled, or worker, MPE. However, there were no areas that exceeded the controlled exposure MPE for workers under this operating scenario. The maximum field level found for this condition was 70.2% of the controlled exposure MPE. It must be remembered, however, that the many wireless communications antennas on the roof will increase the ambient levels of RF, especially in the near vicinity of these antennas.

The impact of continuous operation of all of the wireless telecommunications antennas at the same time in combination with the normal broadcast operation is shown in Figure 7. Under this condition, the maximum MPE is observed to increase substantially to 314.1% although this occurs on only 286 square feet of the roof corresponding to only slightly over 1% of the total roof area. About 83.5% of the roof area has fields exceeding the uncontrolled exposure MPE. This substantially greater roof area of higher RF fields is directly related to the additional fields produced by the many wireless communications antennas. This is evident from the numerous spots in the figure that are represented by red or blue colors.

The contribution of the 72 MHz paging link antennas was examined by removing the theoretically calculated fields from those antennas using the RoofView software. This was accomplished by making custom modifications to RoofView which permitted the computation of those fields, as would be performed during a conventional roof analysis, but then subtracting those results for each pixel on the roof. When this process was accomplished, the maximum RF field on the roof was found to decrease from 70.2% (with the 72 MHz pagers included) to 56.6% of the MPE, thereby increasing the amount of roof area subject to fields less than 20% of the MPE. Under this condition, only 15% of the roof area (3,943 square feet) was found to exceed 20% of the MPE. Figure 8 illustrates the resulting colorized roof map of this hypothetical mode of operation.

RoofView was then exercised by examining the effect of raising all of the 72 MHz paging antennas to six feet above the roof deck. Those antennas already above six feet

were left as is. The results are shown in Figure 9 and indicate that the maximum RF field level would decrease from 70.2% of the MPE (with the paging links at their present mounting heights) to 57.2% of the MPE. RoofView was first used to subtract the calculated fields from each paging link antenna at each roof pixel, and then to add their contribution back into the ambient, measured broadcast field levels for the condition of being raised to six feet above the roof where applicable.

Finally, the result of raising all wireless antennas on the WTC roof to at least six feet was evaluated using RoofView. All antenna mounting heights that were indicated as less than six feet above the roof deck were increased to six feet. Those already mounted greater than six feet above the roof were left as is, similar to the treatment of the 72 MHz paging links discussed above. As expected, this process resulted in significantly lower fields, bringing the projected maximum RF field, found at any place on the roof, down from 314% of the MPE to only 67.2%. Figure 10 illustrates the colorized roof map for this condition. In this case, no area on the roof exceeded 100% of the MPE and the roof area subject to fields greater than the uncontrolled exposure MPE (83.5% before raising the wireless antennas) was reduced to only 32.6%. This substantial reduction in RF field levels supports the common contention that antenna mounting height can play a very significant role in controlling RF fields at roof-top antenna sites.

Tower Maintenance Mode

Figure 11 shows the measurement results obtained during the tower maintenance mode of operation of broadcast facilities with the inclusion of the 72 MHz paging links. In this instance, ambient fields are seen to increase, as would be expected because of RF emissions from the lower mounted auxiliary antennas. The maximum field level observed via measurements for this condition was 147% of the MPE (up from 70.2% of the MPE for the normal broadcast operation with inclusion of the 72 MHz paging links) with almost the entire roof area (96.17%) subject to fields exceeding 20% of the controlled exposure MPE (or 100% of the general public exposure MPE).

With the added RF fields produced by all of the wireless telecommunications antennas operating, the maximum field on the roof is projected to be 352% of the MPE with almost the entire roof (99.52%) exhibiting fields greater than the MPE for general public exposures. Again, localized areas shown in blue on the roof map in Figure 12 illustrate the fact that many of the wireless communications antennas tend to dominate the composite fields in the immediate region about the antennas. Of particular relevance is that observation that 16.5% of the roof area (4,489 square feet) is projected to be subject to fields exceeding 100% of the controlled exposure MPE.

If the contribution of the 72 MHz paging links is removed, in a fashion like that described above, the resulting roof map, shown in Figure 13, shows that the maximum RF field level has been reduced from 147% of the MPE to 138% and the extent of the roof area that is subject to fields exceeding the lower, general public MPE is slightly decreased to 94.3% of the roof surface. This condition projects the expected ambient RF field levels

on the roof top that would be due solely to the operation of the various broadcast stations during the tower maintenance mode.

The RF field mitigation effects of elevating the many wireless antennas to at least six feet above the roof surface is illustrated in Figure 14. In this case, wireless antennas not already mounted at least six feet above the roof were elevated in mounting height through use of the RoofView software. When this was done, the maximum RF field on the roof was found to be 144% of the MPE compared to 352% before raising the antennas and the amount of roof area subject to fields exceeding 100% of the MPE now represents only 2.55% of the roof area. However, 96.4% of the roof area is still at RF levels exceeding the general public MPE.

■ Emergency Backup Operation Scenario

The greatest RF field levels were observed during the hypothetical emergency backup mode of operation wherein the UHF TV stations continued to operate from their *main antennas*, the VHF TV *stations operated* from their lower mounted auxiliary antennas, WCBS (channel 2) remained broadcasting from their main antenna at the WTC and WQCD-FM operated from the master FM antenna at the WTC rather than from their main antenna at the Empire State Building. Under this scenario, which, again, included the operation of the 72 MHz paging links, RF fields as high as 156.3% of the controlled exposure MPE were observed on the roof. Figure 15 illustrates the observed results. Almost 10% of the roof area (2,581 ft^2) is subject to fields exceeding the controlled exposure MPE.

The absolute, worst case scenario is when the contributions of the wireless antennas are included with the composite RF fields produced by the broadcast operations in the emergency backup mode. The computed results from RoofView are seen in Figure 16. The maximum field level is seen to be 373% of the MPE with 99.99% of the roof exceeding the general public MPE. Almost 27% of the roof surface (7,276 square feet) is projected to exceed the controlled exposure MPE.

If the contributions of the 72 MHz paging links or any other wireless antennas are removed from the measured ambient fields, the maximum RF field is projected to reduce to 135% of the MPE with a resulting roof map as illustrated in Figure 17. When this is done, the amount of roof area with fields less than the general public MPE is increased from less than 1% previously to more than 4%. However, there is still 3.25% of the roof (corresponding to 888 ft^2) that is subject to fields exceeding 100% of the MPE.

Should all wireless antennas be mounted at least six feet above the roof deck, a substantial reduction in RF field levels is found to result as seen in Figure 18. Even with this change, however, still, greater than 99% of the roof area is subject to field exceeding the general public MPE and more than 6% of the roof area still exceeds the worker MPE (down from 27% of roof area before raising the antennas).

Other Scenarios

Two additional scenarios were investigated. The projected fields that would result from operation of just the wireless communications antennas, without the influence of the 72 MHz paging link antennas or from any broadcast operations, were evaluated through the normal use of RoofView and these results are shown in Figure 19. Under this scenario, a maximum field of 273% of the MPE was found and 36.3% of the roof area was found to exceed the public MPE limits. Only 0.32% of the roof was projected to exhibit fields greater than the controlled exposure MPE. Figure 19 illustrates the localized impact of the wireless antennas on ambient fields.

Finally, the potential for strong, localized RF fields in the 800-900 MHz frequency range was evaluated by invoking the cylindrical spatial peak mode of operation for RoofView. In this instance, the cylindrical spatial peak model produces RF fields that are 3.0 times greater than the spatial average model; this is based on evaluation of the ratio of spatial peak and average fields near vertical collinear antennas (see Tell, 1996). Actual ratios of the spatial peak and average fields can range, generally, between two and four times but in many practical applications, a figure of three times represents a good average value. The spatial peak model finds application in instances where it is of interest to estimate the absolute maximum field values that could be found during an RF field survey near wireless antennas. Alternatively, evaluating RF exposure situations relative to the use of protective clothing where peak power density values have been specified by the manufacturer could be another practical application. For example, in some working conditions, it may be acceptable for workers to not wear head protection for RF fields. The issue of partial body exposure to RF fields is importantly related the spatial peak value of RF fields rather than that value as averaged over the whole body

Figure 20 illustrates the roof map found when calculating fields based on the spatial peak values for just those antennas operating at greater than 800 MHz. Of special note is that none of the resulting projected fields exceed 276% of the controlled exposure MPE, and these occur only in the immediate vicinity of several of the wireless antennas.

Overall Observations, Insights and Conclusions

Performing any study of RF fields of this magnitude represents a serious challenge. Simply the required coordination among so many stations, personnel and transmitter shut-downs can lead to complications in carrying out the project. Nonetheless, this study included measurements at 889 different points on the roof of the WTC at three different times. In this context, this study is believed to represent the most comprehensive set of measurements performed to date at the WTC north tower. It also provides considerably more spatial resolution detail of the RF field distributions on the roof than in any other study heretofore performed at the WTC. The extensive analytical approach used to assess the contribution of RF fields from the many wireless telecommunications antennas also formed a major part of the overall study and allowed insight to the way in which wireless antennas can influence the ambient fields at a major broadcast site.

The three different measurement conditions used in this study clearly demonstrated progressively stronger RF fields on the roof. Table 8 summarizes all of the various measurements and analyses included in this study. For example, the measurement data, without any computed input from the wireless communications antennas, other than the 72 MHz paging links that could not be turned off during the bulk of the measurement periods, show maximum field levels ranging from 70.2% of the controlled exposure MPE to 147% MPE for the tower maintenance mode to 156% MPE for the emergency backup mode of operation. This increase in maximum field level makes sense due to the use of lower mounted auxiliary antennas. With only broadcast stations and the 72 MHz paging links active, the extent of roof area exceeding the controlled exposure MPE changed from zero to as much as 9.5% under the emergency backup mode of operation.

When the additional contributions from the many wireless communications antennas are added to the already existing background of RF fields produced by the broadcast facilities, maximum field levels are found to rise substantially being in the range of 314% to 373% of the MPE, depending on conditions. Using the methodology described above for estimating the RF field levels that would exist on the roof if no wireless antennas were to be operative, the maximum field levels were projected to range from 56.6% MPE to as much as 135.2% MPE with the extent of the roof subject to fields exceeding the general public MPE ranging from as low as 14.5% to 99.07% of the roof area. Obviously, however, the presence of the many wireless communications antennas on the roof leads to the possibility of substantially greater fields, near these antennas, and the extent of roof area exhibiting higher fields.

An immediate observation from this study is that large areas of the roof exhibit RF fields that can substantially exceed the MPE for uncontrolled exposure or the general public. Presently, there exist no signs to indicate the presence of strong RF fields that exceed the general public MPE. The new RF rules adopted last year by the FCC specify that transmitter sites which present the potential for human exposure to RF fields that exceed the more stringent public, or uncontrolled exposure, MPEs must also make such individuals "fully aware" of this potential. The FCC has indicated that the use of appropriate signs at the site can be one way of providing this awareness. To comply with the new FCC rules, the roof must be posted to indicate the presence of RF fields that exceed the general public MPE set by the FCC. This conclusion is irrespective of the operation of any of the wireless communications equipment at the WTC; even without any contribution from the wireless antennas, almost 15% of the roof exceeds the more stringent public MPEs.

A related observation is that the RF fields on the roof of the north tower, in many instances, not only exceed the general public MPE but also the controlled exposure, occupational MPE set by the FCC. Because of this, the roof should be designated a controlled environment and be so posted Beyond posting of the site, the development and implementation of an RF safety program should be considered for workers who have access to the roof. The safety program should contain site specific procedures related to

work on the roof to insure compliance with the FCC rules. For example, areas that should be avoided could be identified on the roof and declared in the written program materials that would be provided to roof workers. All individuals who have access to the roof should be required to be presented with the RF safety program materials so that there is no question about them being informed of the presence of RF fields on the roof and appropriate procedures for reducing their exposure to help maintain compliance with FCC rules at the site.

The maximum RF field levels determined in this study are generally consistent with those found during an earlier study conducted by Jules Cohen & Associates, P.C.[5] During a study conducted in 1986, which included both broadband and narrowband measurements of RF fields, during the normal broadcasting condition, no areas on the roof were found that exceeded the RF rules then adopted by the FCC. Those rules, for the frequency range applicable to the WTC roof antennas, were identical to the new rules adopted last year by the FCC for controlled exposure or occupational situations. During the tower maintenance mode of operation, Cohen found one area in the northeastern part of the roof that exceeded the FCC rules. In personal communications with Mr. Cohen, it was disclosed that he did notice elevated fields in the near vicinity of some of the roof-mounted wireless communications antennas.

The strong effect of raising wireless antennas on the resulting roof level RF fields was observed through the study. Perhaps the most important finding of the study, relative to bringing the site into compliance with FCC rules on human exposure, is that associated with operating the wireless communications antennas with a minimum elevation of six feet above the roof. By assuming that all of the wireless antennas are mounted at least six feet above the roof, the projected RF fields on the north tower roof during normal broadcasting operations are all less than the controlled exposure, occupational MPE set by the FCC. This one mitigation measure would be expected to result in maximum fields no greater than about 57% of the occupational MPE and would leave only 14% of the roof area exceeding the general public MPE. Selective mounting height increases could also prove effective in reducing roof-top fields; those antennas operating in the 30-300 MHz frequency band, wherein the FCC limits are most restrictive, could provide substantial improvement in the ambient RF field situation without having to modify all antennas.

In areas where RF fields may exceed the general public MPEs, it would be deemed appropriate to post a Notice sign to indicate the presence of such fields. A Caution sign would be appropriate, however, to indicate areas with fields that may exceed the occupational MPEs. With the present antenna configuration at the WTC north tower for wireless antennas in conjunction with the ambient broadcast fields, the Caution sign would be required since it is possible, under this scenario, to find areas that do exceed the occupational MPE. In the event that that the various wireless antennas were to be raised to a minimum height of six feet, the measurement and analysis results suggest that while the maximum spatially averaged RF fields on the roof would, then, not exceed the higher

[5] Now, Denny and Associates, P.C., Washington, DC, Jules Cohen is a consultant to the firm. Field Strength Measurments World Trade Center, New York, New York.

occupational MPE, a substantial amount of the roof area would still be subject to fields that exceed the uncontrolled exposure MPE. Hence, even with raising the antennas, the roof needs to be appropriately posted but, under this specific condition, should be able to accomplished with Notice signs as opposed to Caution signs.

In the event that the antennas are not raised, or that not all of the wireless antennas are raised, areas on the roof subject to RF fields that may, from time to time and depending on wireless communications transmitter activity, exceed the controlled exposure MPEs of the FCC, should be identified and marked. Part of the work procedures for roof workers should, then, include awareness of those areas to avoid. Depending on the degree of detail desired in a safety program, limits on access time could be assigned to specific areas of the roof. To accurately implement such an approach, however, it is recommended that additional measurements be taken on the roof to more clearly define those specific areas. In no circumstance, when theoretically projected fields approach applicable human exposure limits, should complete reliance be placed on just analysis results. Direct measurements will provide the added degree of confidence in assessing potential exposure in those cases. Also, it must be recognized that wireless antenna sites are often very dynamic in terms of equipment changes. Hence, results obtained at one time may not accurately portray RF field conditions at a later time when additional antennas or other operating parameters have changed.

The analysis results provided in this report are based on the conservative assumption that all wireless communications transmitters connected to roof-top antennas are active. This approach has been taken in the interest of erring on the side of caution and since attempting to determine, in any rigorous and defensible way, the transmitter up-time profiles for each transmitter active at the site would be a very major task. Nonetheless, it should be recognized that under normal operating conditions, the RF field levels on the roof of the WTC will vary throughout the day due to changes in transmitter activity, or up-time. Such normal communications operations lead, generally, to the observation that the likelihood of simultaneous operation of all transmitters is rare and, hence, the field projections arrived at in this report will generally overstate both the magnitude of RF fields at various points and the roof area subject to such fields. However, without direct measurements of typical transmitter up-times for the many wireless communications transmitters at the WTC, using appropriate computer controlled scanning receivers, assigning values for transmitter up-times inherently contains considerable uncertainty with a corresponding uncertainty in the projected field levels. In view of such uncertainties and the additional time and effort that it would take to fully assess the up-time characteristics of all of the antennas, it was decided that this evaluation should explore the maximum possible RF field levels to which individuals might be exposed. Clearly, informed judgment on times of day during which most transmitters will be operating at a high duty cycle may be useful in guessing when fields may be at higher or lower levels. But such 'guestimates' should not be used for declaring compliance with the FCC rules on RF exposures unless supported by some kind of on-site measurement data.

Another reason for using a 100% up-time assumption in these analyses is that any on-site data collection related to transmitter up-times must be collected for a sufficiently

long time to provide acceptable statistical confidence for projecting the up-time of any specific transmitter at any particular time of the day. In practical terms, this means that, contrary to the situation with broadcast transmitters in which signal levels remain constant throughout the day, repetitive measures of the wireless communications transmitter up-times, perhaps for multiple days, must be acquired to provide the required measure of statistical confidence for assigning up-time profiles. Application of these transmitter up-time profiles for the many antennas would then mean that each roof map that depicts the projected RF field levels for a particular condition, such as normal broadcasting or the tower maintenance mode, would carry with it some statement of confidence that the estimated field levels are actually at that level at some particular time of the day. All of these technical and practical considerations led to the worst case approach used in this study. By applying the results obtained in this study, while acknowledged to generally overstate the composite RF field levels on the roof, the extent of the roof area subject to specific field levels and the projected field levels themselves should provide a margin of safety when defining site specific work procedures.

A final observation is that related to maximum expected field levels on the roof for frequencies in the 800 MHz to 1000 MHz range. The standards against which these analyses are to be compared are based, generally, on whole-body averaged specific absorption rate (SAR), the rate at which the energy contained within the electromagnetic field is absorbed within the tissues of the body. The whole-body averaged SAR is limited to a value of 0.4 watts per kilogram (W/kg) of body mass for controlled exposures and to a value of 0.08 W/kg for uncontrolled exposures. For this reason, field measurements are normally performed by determining the spatially averaged value of plane-wave equivalent power density as performed in this study. Besides the whole-body averaged SAR, the limits are also based on preventing spatial peak SARs from exceeding 8 W/kg in any one gram of tissue in the body for controlled exposure environments.[6] The local, peak SAR in the body is usually, for near-field exposures, related to the local value of equivalent power density to which the body is exposed rather than the spatially averaged value.

A maximum value of the RF fields associated with transmitters operating in the 800 and 900 MHz bands was explored by invoking the spatial peak mode of calculation within RoofView. In this case, an upper value of 276% of the controlled exposure MPE was found near some of the wireless antennas. This finding has relevance relative to the potential use of RF protective clothing as one possible exposure mitigation at the WTC.

In an earlier investigation of the effectiveness of a particular RF protective suit, Tell (1997) found that, for near field exposure conditions used in the study at 835 MHz, exposure of the unprotected head did not result in peak SARs exceeding the underlying basis of 8 W/kg until the incident RF field exceeded 325% of the controlled exposure MPE. This suggests that, should RF protective clothing be used as a possible exposure mitigation method at the WTC, wearing of a protective hood assembly by workers would not necessarily be required. The coverall type of suit, without the hood, would, of course,

[6] Higher peak SARs are permitted in the extremities where 20 W/kg is acceptable for the hands, wrists, ankles and feet for controlled exposure situations.

have to be worn to insure that worker body exposures did not exceed limits prescribed by the FCC.

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Table 1. Television and radio broadcast facilities on the north tower of the World Trade Center. Heights above the roof are approximate.

Call sign	Channel	ERP (kW)	Height above roof to center of radiation (ft)
WNBC	4	17.4/3.47	335
WNYW	5	17.4/3.47	335
WPIX	11	58.9/11.7	309
WWOR	9	47.9/4.79	282
WNET	13	43.7/4.8	282
WABC	7	64.6/6.46	256
WNYC	31	2820/282	206
WCBS	2	21.4/4.3	200
WNJU	47	4570/457	153
WNBC-aux	4-	17.4/3.47	92
WNYW-aux	5	17.4/1.74	86
WKCR-FM	89.9	0.63	42
WPAT-FM	93.1	5.4	42
WNYC-FM	93.9	5.4	42
WQCD-FM aux	101.9	3.3	42
WABC-aux	7	64.6/6.46	49
WPIX-aux	11	58.9/11.9	38
WNET-aux	13	47.9/4.8	32
WWOR-aux	9	47.9/4.79	18

Table 2. Calibration data for the Narda Model 8742 broadband, isotropic electric field probes available for measurements at the World Trade Center. After initial evaluations, probe serial number 1004 was not used during for the main set of measurements.

Probe Calibration Data Supplied by Narda						
Probe SN	1004	2011	2016	2018	2019	2020
Freq(MHz)	Mar 97	Demo	Dec 96	May 97	Dec 96	Dec 96
	1004	2011	2016	2018	2019	2020
[redacted]						
Max	1.57	1.47	1.41	1.51	1.40	1.38
Min	0.64	0.68	0.71	0.66	0.71	0.73
Max(dB)	1.958997	1.673173	1.492191	1.789769	1.46128	1.398791
Min(dB)	-1.9382	-1.67491	-1.48742	-1.80456	-1.48742	-1.36677

Table 3. Summary of correction factors for probes actually used during RF measurements at the WTC within the applicable frequency range. Calibration date is shown above the serial number.

	Demo	Dec-96	May-97	Dec-96	Dec-96
Freq. (MHz)	SN 2011	SN 2016	SN 2018	SN 2019	SN 2020
27.12	1.23	1.26	1.43	1.22	1.17
100.00	0.94	0.90	1.06	0.90	0.87
300.00	1.29	1.25	1.24	1.19	1.20
500.00	0.94	0.90	0.83	0.89	0.87
750.00	0.74	0.71	0.67	0.74	0.73
915.00	0.84	0.81	0.73	0.78	0.74
[redacted]					
Max(dB)	1.11	1.00	1.55	0.86	0.79
Min(dB)	-1.31	-1.49	-1.74	-1.31	-1.37
[redacted]					

Overall average low reading (%)	-21.58
Overall average high reading (%)	39.47
Overall average low reading (dB)	-1.06
Overall average high reading (dB)	1.44

Table 4. Observed variation in measured percentages of spatially averaged MPE over all orientations and three repetitions for all ten evaluation points on WTC roof for each measurement team. A total of 120 measurements were obtained at the ten points by each team.

Team	Mean deviation (%)	Positive deviation (dB)	Negative deviation (dB)
A	13.85	0.56	-0.65
B	14.08	0.57	-0.66
C	9.93	0.41	-0.45
D	14.42	0.59	-0.68
E	10.75	0.44	-0.49
Average	12.61	0.51	0.59

Table 5. Measured values of fields in high resolution area of WTC roof (% MPE)

28.2	29.5	30.6	[illegible]	[illegible]	31.9	[illegible]	[illegible]	39.0	38.5	42.0
25.4	27.2	27.8	28.3	[illegible]	29.8	[illegible]	33.1	[illegible]	41.8	42.7
28.4	30.1	32.8	31.8	[illegible]	32.6	[illegible]	35.4	36.7	39.6	44.6
28.5	30.5	31.2	31.8	[illegible]	35.3	[illegible]	[illegible]	38.0	39.8	41.0
28.4	29.9	31.9	33.1	[illegible]	35.0	[illegible]	[illegible]	[illegible]	41.1	41.5
28.7	30.8	[illegible]	33.3	32.2	32.7	32.8	[illegible]	38.8	42.2	47.2

Table 6. Interpolated values of fields in high resolution area of WTC roof based on measured values in colored cells only (% MPE)

28.2	28.9	29.7	30.4	31.1	31.9	[illegible]	[illegible]	38.0	40.0	42.0
28.3	29.0	29.8	30.5	[illegible]	32.0	34.2	[illegible]	38.5	40.7	42.8
[illegible]	29.1	29.9	30.6	31.4	32.1	34.5	36.8	39.1	41.4	43.7
28.5	29.2	30.0	30.8	[illegible]	32.4	[illegible]	[illegible]	40.0	[illegible]	45.1
28.6	29.3	30.1	30.9	[illegible]	32.5	[illegible]	[illegible]	[illegible]	43.5	46.2
28.7	[illegible]	30.3	31.1	[illegible]	32.7	[illegible]	[illegible]	41.4	44.3	47.2

Table 7. Percentage difference between interpolated values and measured values (%). Colored cells represent cells in which [illegible] measurement data were used to interpolate other values

	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	

Table 8. Summary of RF measurements and analysis on roof of WTC north tower Each condition is referenced to a specific colorized roof map that illustrates the distribution of RF fields on the WTC roof

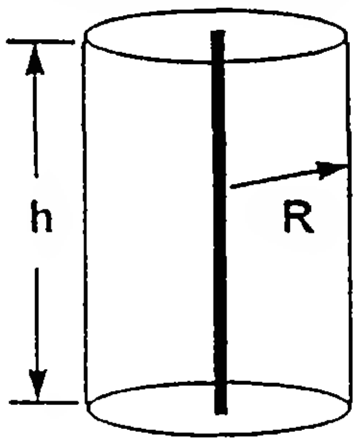
Conditions of RF measurements and/or analysis	Max MPE (%)	Percent of roof area with spatially averaged RF fields (%)		
		[redacted]	21-50	[redacted]
Normal broadcast + 72 MHz pagers (Fig. 6)	70.2	[redacted]	35.94	[redacted]
Normal broadcast + all wireless (Fig. 7)	314.1	[redacted]	60.48	[redacted]
Normal broadcast w/o 72 MHz pagers or any other wireless (Fig. 8)	56.6	[redacted]	14.47	[redacted]
Normal broadcast with 72 MHz pagers ≥ 6 feet above roof surface (no other wireless) (Fig. 9)	57 2	[redacted]	19.55	[redacted]
Normal broadcast with all wireless antennas ≥ 6 feet above roof surface (Fig 10)	67.2	[redacted]	32.32	[redacted]
Tower maintenance mode + 72 MHz pagers (Fig. 11)	147 0	[redacted]	43.11	[redacted]
Tower maintenance mode + all wireless antennas (Fig 12)	352.0	[redacted]	20.93	[redacted]
Tower maintenance mode w/o 72 MHz pagers or any other wireless (Fig. 13)	138.3	[redacted]	48.18	[redacted]
Tower maintenance mode with all wireless antennas ≥ 6 feet above roof surface (Fig. 14)	144 3	[redacted]	46.47	[redacted]
Emergency broadcast backup + 72 MHz pagers (Fig 15)	156.3	[redacted]	31.89	[redacted]
Emergency broadcast backup + all wireless (Fig. 16)	373 0	[redacted]	14.37	[redacted]
Emergency broadcast backup w/o 72 MHz pagers or any other wireless (Fig. 17)	135 2	[redacted]	40.56	[redacted]
Emergency broadcast backup with all wireless antennas ≥ 6 feet above roof surface (Fig. 18)	149.3	[redacted]	33 46	[redacted]
Wireless antennas w/o 72 MHz pagers and no broadcast (Fig 19)	273 9	[redacted]	32.94	[redacted]
Spatial peak from only wireless antennas > 800 MHz (Fig 20)	276 0	[redacted]	0 79	[redacted]

Appendix A

A Brief Description of the RF Field Calculation Models Used In RoofView

The underlying calculation engine within RoofView for near-field analysis is based on a cylindrical model for vertical collinear antennas. In concept, when sufficiently close to an antenna, the beam of the antenna has not formed and, hence, the far-field gain of the antenna cannot be exhibited. This means that a vertical collinear antenna having a gain of 10 dBd (decibels relative to a halfwave dipole antenna) cannot exhibit 10 dBd of gain very close to it. Thus, calculations of RF field power densities close to such antennas, using a far-field model, will generally greatly over predict the field magnitude. When in close proximity to such antennas, alternative calculation models should be used to more accurately evaluate the RF fields.

RoofView uses a near-field method of computing the field based on assuming that the total input power delivered to the antenna, at its input terminal, is distributed over an imaginary cylindrical surface surrounding the antenna (see Figure A-1). The height of the cylinder is equal to the aperture height of the antenna while the radius is simply the distance from the antenna at which the field power density is to be computed. Within the aperture of the antenna, this approximation is quite accurate but as the antenna is elevated



$$S = \frac{P}{2\pi Rh}$$

Figure A-1. Distribution of power over surface of an imaginary cylinder.

above the region of interest, the model output must be corrected for mounting height. For example, when compared to a method of moments technique in which the RF field is calculated at a high spatial resolution parallel to a vertical collinear type of antenna, the spatial average value of the field, within the aperture dimension, is closely approximated by the value obtained from the cylindrical model. In one evaluation (Tell, 1996), the differences in spatial average values of the field were found to range from about 0.1 dB to about 1 dB between the two computational approaches, depending on the distance from the antenna.

RoofView performs the correction for antenna mounting height automatically in its calculations, allowing the user to conveniently explore the effects of antenna mounting heights relative to controlling excessive RF field levels on roof-top antenna sites. RoofView allows for antenna mounting heights between 0 and 10 feet relative to the roof surface. If a mounting height less than 0 feet is input, RoofView uses 0 as the mounting height. If a value greater than 10 feet is input, RoofView uses the correction applicable to a mounting height of 10 feet.

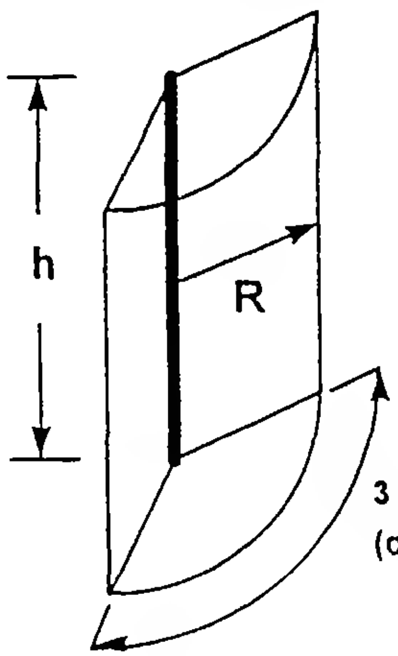
The primary application of RoofView is in the near-field vicinity of roof mounted antennas. The cylindrical model, while highly accurate in the near-field region, becomes less accurate with increasing distance from the antenna and, eventually, will over estimate the magnitude of the RF fields at long distances from the antenna. There exists a cross-over point at which the near-field model and the far-field model will produce the same value of power density. Beyond this point, typically in the range of 1-5 times the aperture height of the antenna, the far-field model will yield more accurate values of power density. A general rule is that the appropriate model to use yields the lower power density at a given calculation distance. For example, closer to the antenna under study, the near-field model yields lower values of power density and provides more accurate predictions. Farther from the antenna, the far-field model yields lower values of power density and is the right model to use. Care must be used, however, in trying to compare the outputs of various models since the cylindrical model automatically produces values of the spatially averaged power density, the field parameter needed for direct comparison with most of the applicable standards for human exposure. Far-field models generally do not automatically perform this operation and, hence, it is possible that one might erroneously compare a <u>spatially averaged</u> power density to a <u>spatial peak</u> power density. If this occurs, the observed cross-over point for the two models will generally be farther from the antenna than the actual dividing line between near- and far-field models; remember that the spatial peak power density from the far-field model will occur farther from an antenna than the point at which an equivalent, spatially averaged power density will occur. RoofView provides for a user selectable distance, referenced to the aperture height, at which the calculation engine begins to allow the computed field density to decrease according to the inverse square law. For distances up to this limit, the near-field model is applied; at further distances, the near-field computed power density at the limiting distance is then adjusted downward in accord with the inverse square law.

One important observation from near-field analysis of RF fields is that, for a fixed antenna input power, very close to an antenna, the RF fields will be greater for smaller antennas. This fundamental concept is contrary to the way many communications engineers think about antennas. Traditionally, it is well understood that larger antennas offer greater gain than smaller antennas, and, therefore, will result in stronger signals assuming the same input powers. This concept is true in the far field of an antenna but is not true in the near field. This is because the gain specified for antennas by manufacturers is always associated with the far field. So, a short paging antenna, though it may have significantly lower gain than a much taller model, will exhibit much higher power densities near it than the higher gain, taller model with the same input power. You can explore this

phenomenon easily with RoofView by adjusting the aperture height of antennas and watching the change in the colorized roof map. Smaller antennas result in greater near-field power densities than larger antennas. This can become particularly important when considering very short aperture antennas such as those contained in three-way and four-way antennas that contain multiple radiating, short apertures.

The cylindrical model for computing RF fields in the near-field region of vertical collinear antennas is discussed in some depth in various technical reports including Tell (1995, 1996).

The cylindrical model may be modified to account for azimuthal directivity by increasing the power density calculated for the simple full cylinder model by a factor equal to the number of times that the 3 dB beam width will divide into 360 degrees. This approach provides a conservative estimate of the RF field in the direction of maximum radiation since the actual azimuthal dispersion of power extends beyond the 3 dB beam width limits. Hence, when the 3 dB beam width is used, RF fields will generally be over estimated since all of the radiated power is assumed to be spread over a partial cylindrical surface that is smaller than that over which it is actually dispersed (see Figure A-2).



$$S = \frac{360\ P}{\theta_{BW}\, 2\pi R h}$$

Figure A-2. Modified cylindrical model for sector-type antennas assumes that all power is radiated through the reduced portion of a partial cylindrical surface.

The Super Tellamatic MPE Power Density Calculator contained within RoofView provides for three different models for computing RF fields. Cylindrical spatial average, cylindrical spatial peak and far-field spatial peak models may be applied. The cylindrical spatial peak model produces RF fields that are 3.0 times greater than the spatial average model; this is based on evaluation of the ratio of spatial peak and average fields near

vertical collinear antennas (see Tell, 1996). Actual ratios of the spatial peak and average fields can range between two and four times but in many practical applications, a figure of three times represents a good average value. The spatial peak model may find applications in instances where one is interested in estimating the maximum field values that could be found during an RF field survey of an antenna site. Alternatively, evaluating RF exposure situations relative to the use of protective clothing where peak power density values have been specified by the manufacturer could be another practical application. For example, in some working conditions, it may be acceptable for workers to not wear head protection for RF fields. The issue of partial body exposure to RF fields may be importantly related the spatial peak value of RF fields rather than that value as averaged over the whole body.

The far-field spatial peak model makes use of the antenna gain and includes a ground power reflection factor of 2.56 as specified in FCC documents for including in routine RF field evaluations.

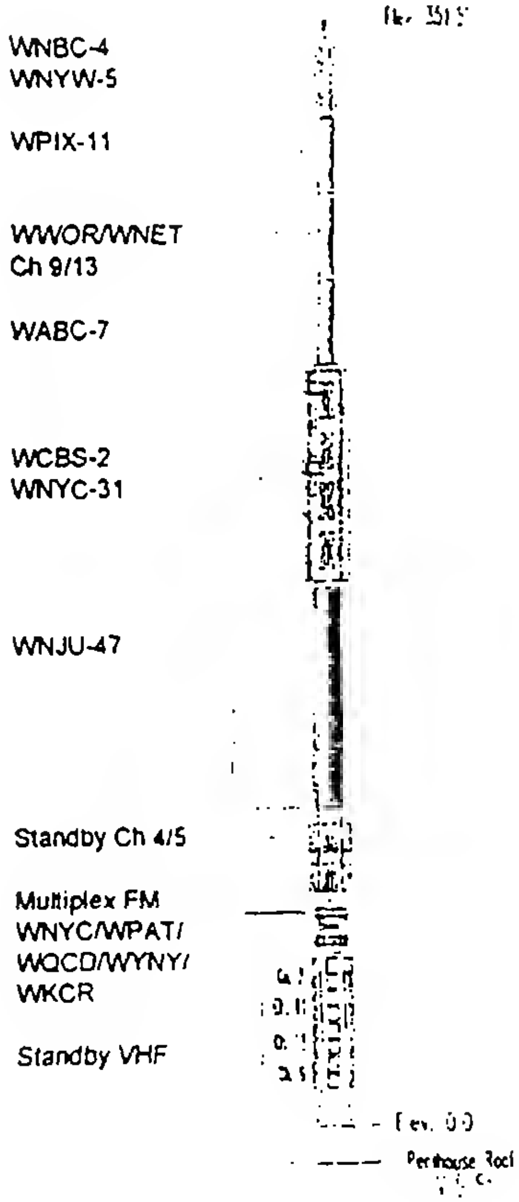


Figure 1. Drawing of antenna mast on the north tower of the World Trade Center.

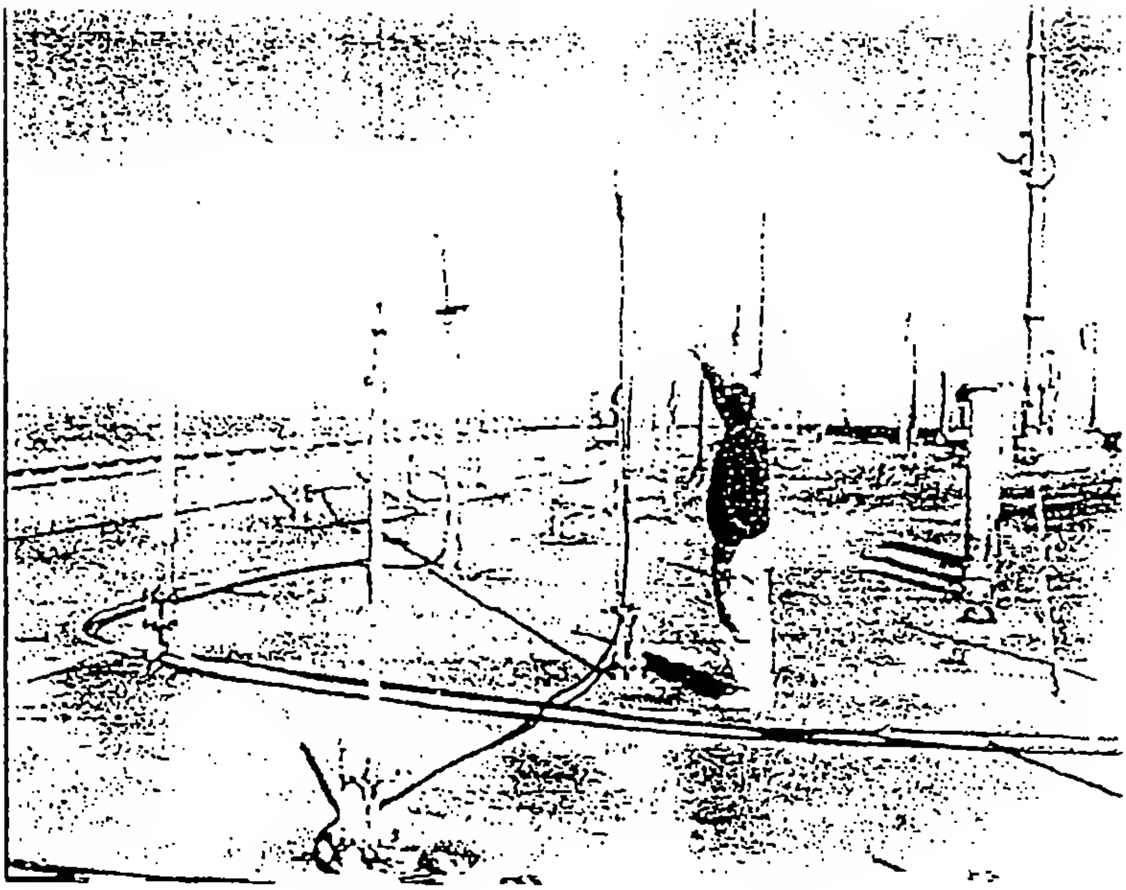


Figure 2. View of some of the many wireless communications antennas mounted on the roof of the WTC. Most antennas are mounted on 10 foot centers but in many cases, due to obstructions, alternate spacings are used. Many of the antennas are mounted close to the roof and some are elevated considerably above the roof surface.

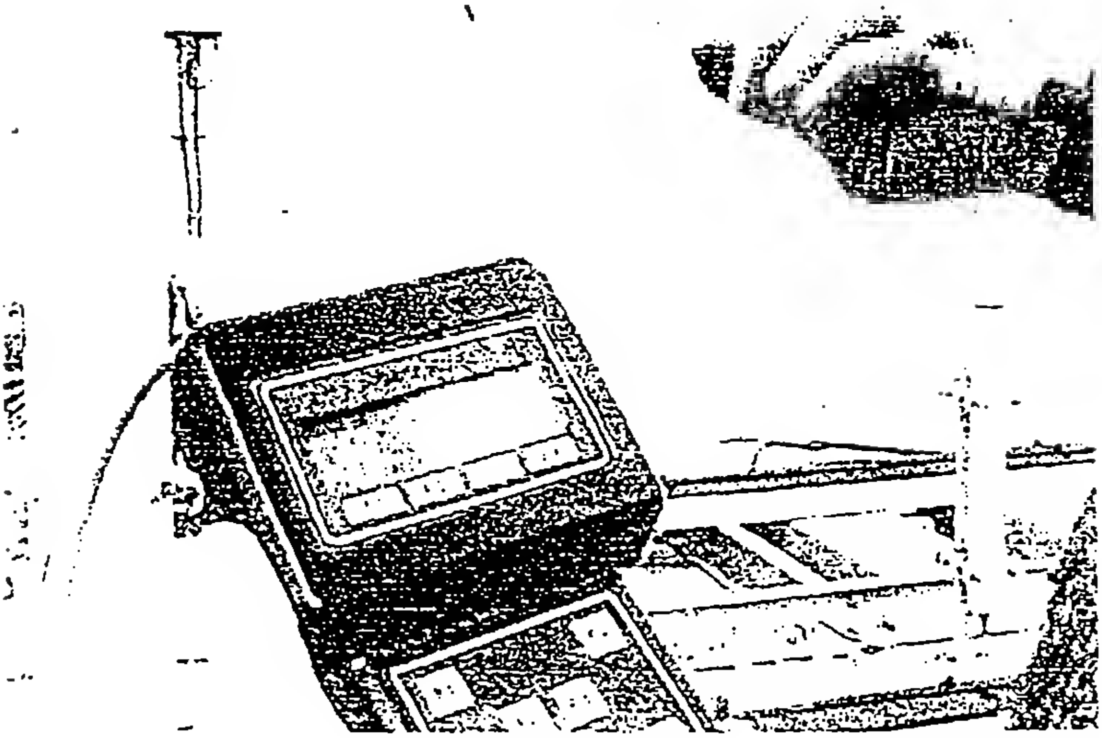


Figure 3. Photograph of the Narda Model 87?8 digital RF survey meter and the Model 8742 broadband, isotropic, frequency shaped electric field probe used during the field measurements. A total of five measurement [illegible], each using one of these meter-probe combinations, were used to acquire the [illegible] of measurement data during the [illegible]

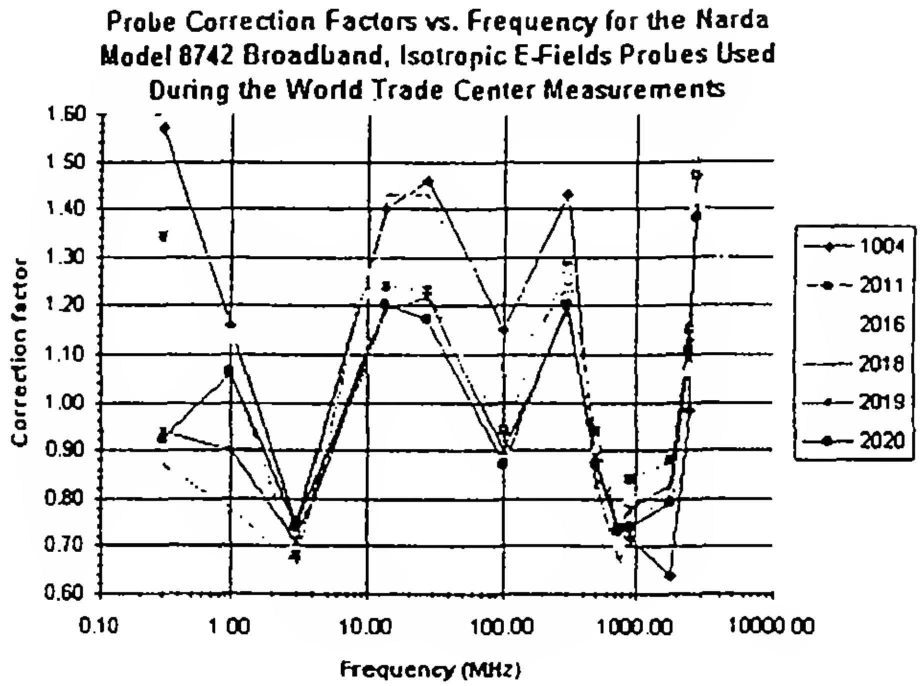


Figure 4. Graph showing the distribution of correction factors for the Narda Model 8742 broadband, isotropic frequency shaped electric field probes used during the WTC RF measurement project The probe with serial number 1004 was not used during the actual survey process due to its generally greater correction factor at most frequencies All probe correction factors are seen to comply with the manufacturer's specification of a maximum deviation of ±2 dB from the frequency variation of the standard for human exposure adopted by the FCC in the frequency range of 0.3 MHz to 2,000 MHz..

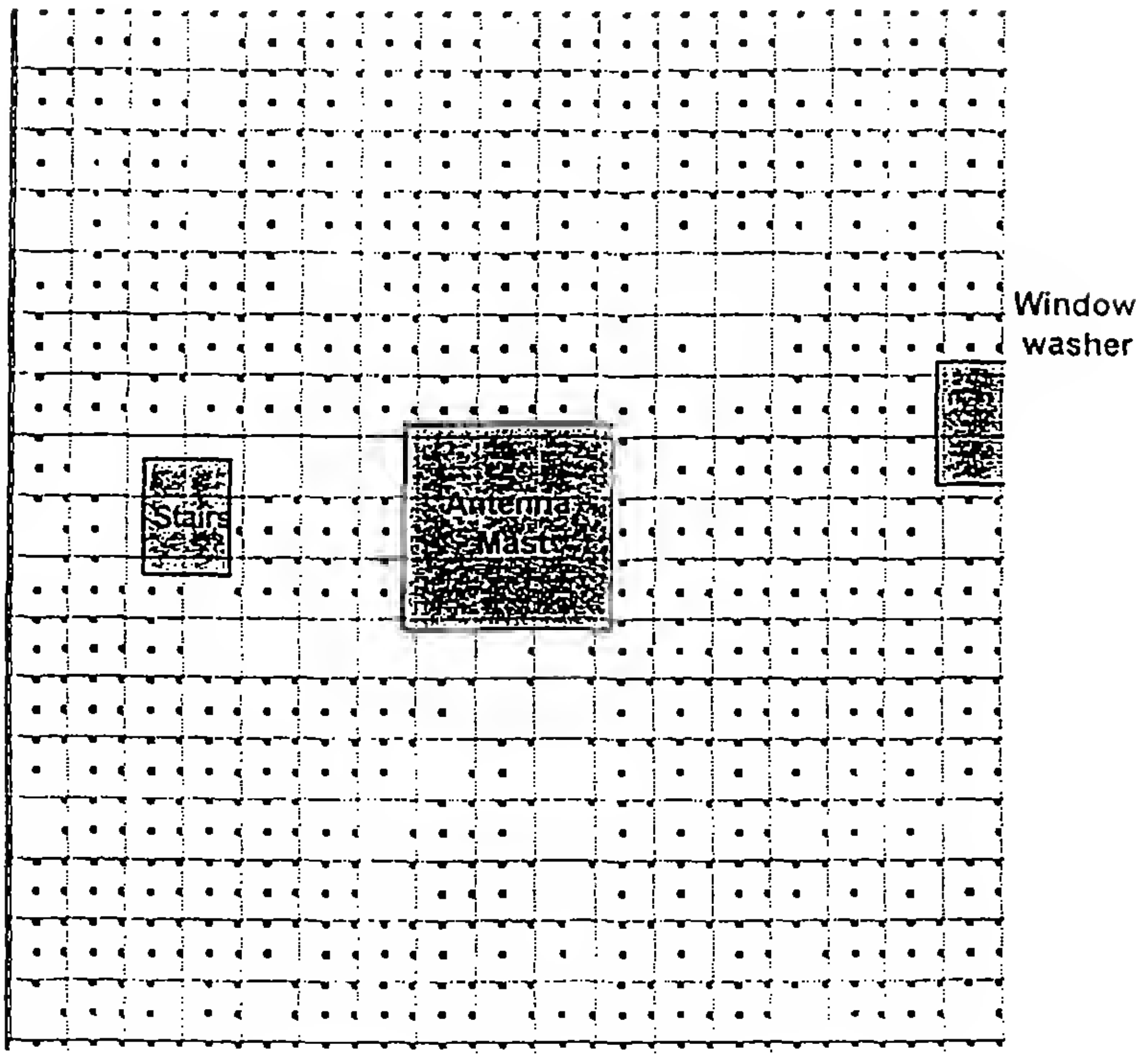


Figure 5. WTC roof map showing the location and distribution of all included 889 measurement points The overall measurement area was 170 feet by 170 feet with measurement points spaced generally five feet apart except when a point fell within 2.5 feet of an existing roof-mounted antenna or other metallic structure such as cable trays and roof-mounted lights that might perturb the local fields

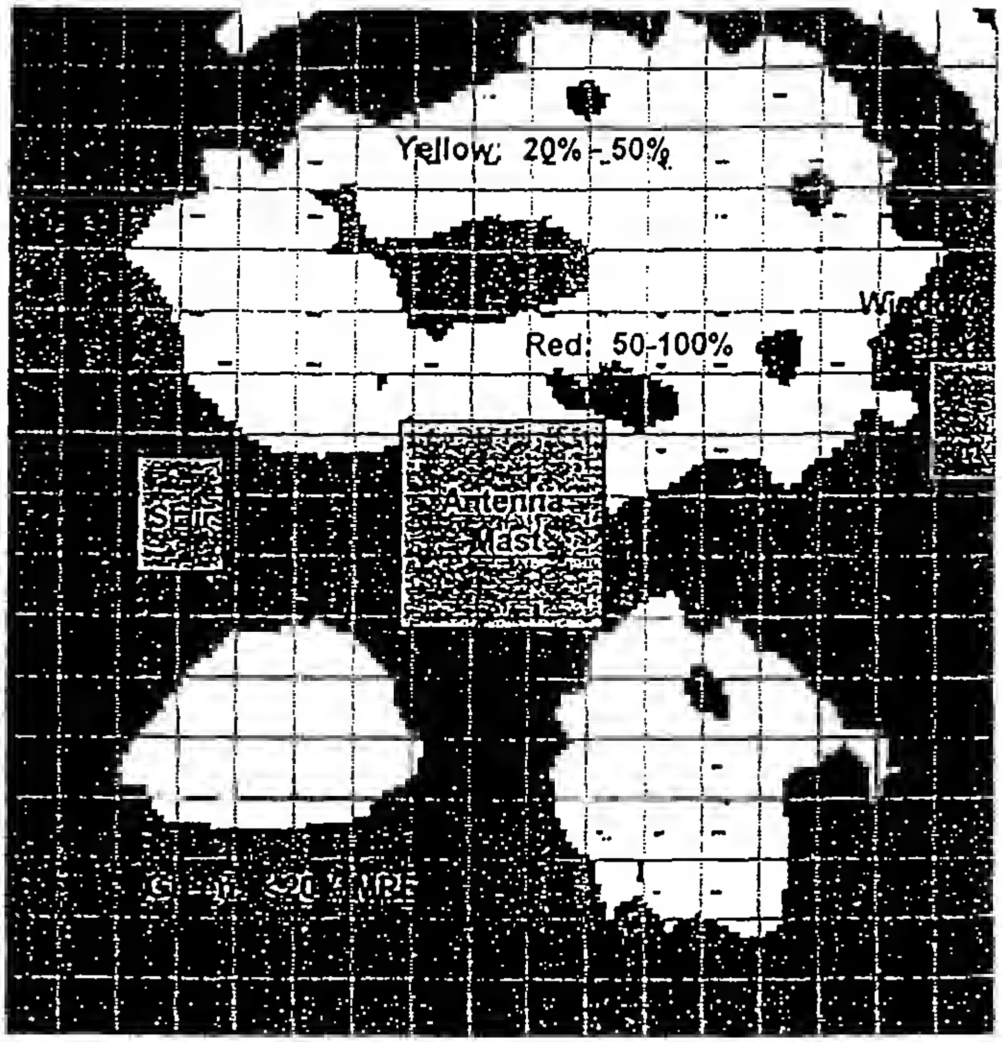


Figure 6. Roof map showing measured ambient RF fields on roof of north tower of World Trade Center during normal broadcast operations with contributions from 72 MHz paging links included. Maximum field is 70.2% MPE

Statistical summary of RF Fields on WTC roof (see Figure 6)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	17070	62.75
21-50	9778	35.94
51-100	350	1.31
>100	0	0.00

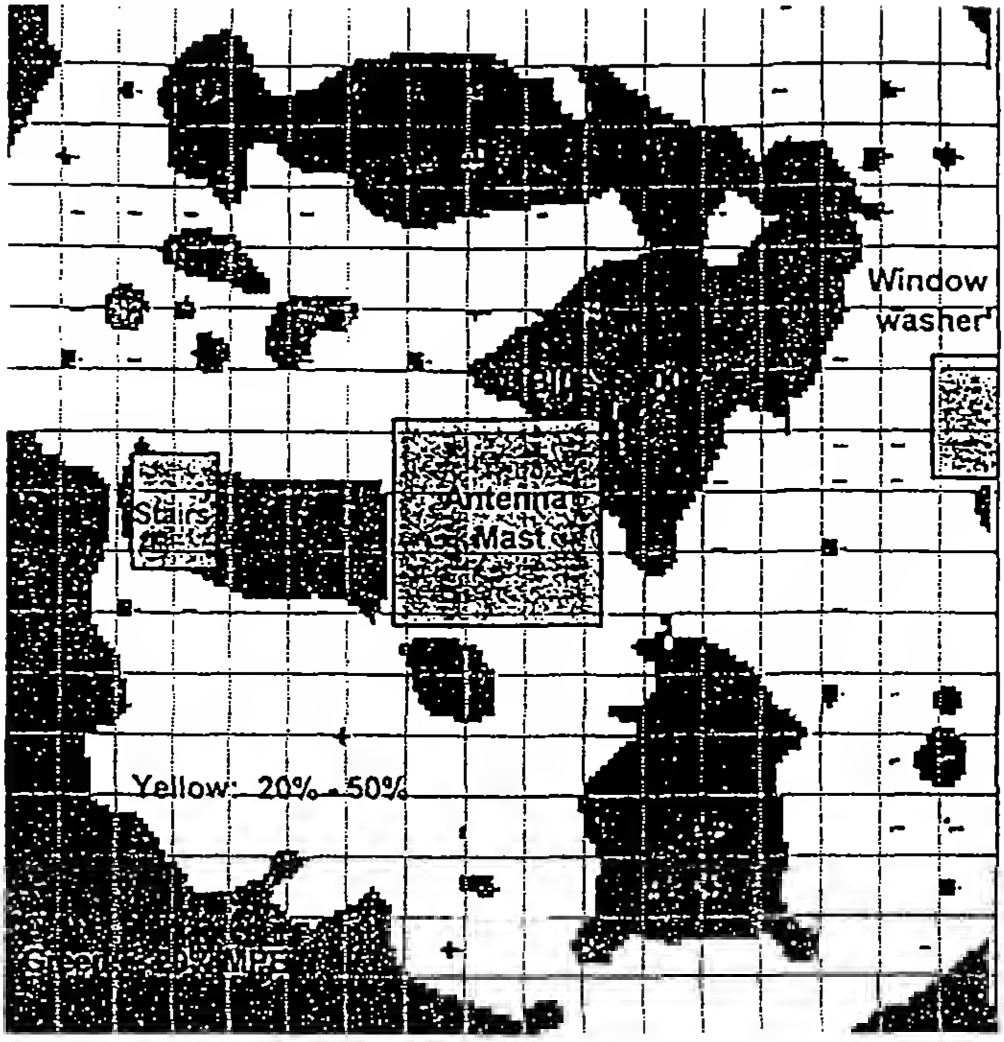


Figure 7. Roof map showing combined RF fields from measured ambient fields of normal broadcasting operations with calculated contribution of all wireless telecommunications antennas. Maximum field is 314 1% MPE

Statistical summary of RF Fields on WTC roof (see Figure 7)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	4502	16.55
21-50	16454	60.48
51-100	5963	21 92
>100	286	1 05

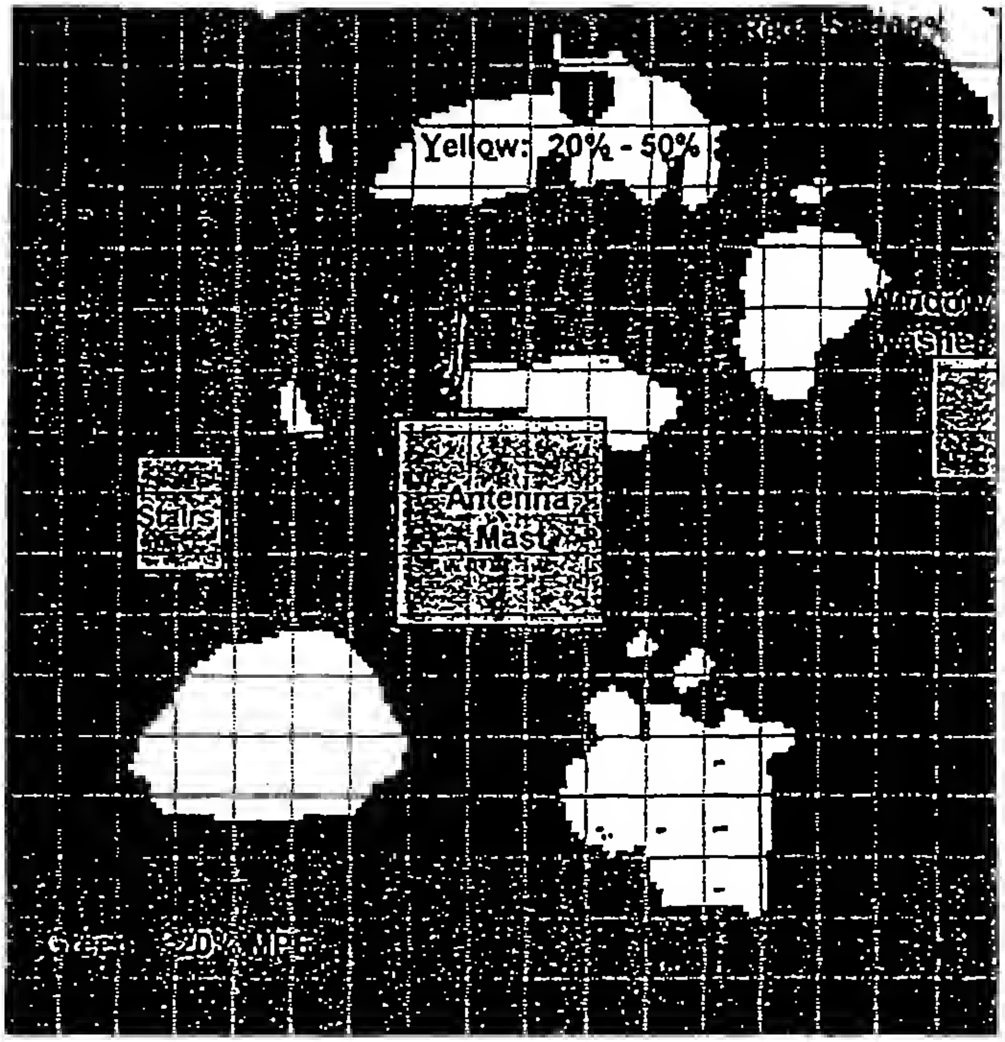


Figure 8. Roof map of normal broadcast ambient RF fields with contribution of 72 MHz paging links removed via analysis with RoofView Maximum field is 56.6% MPE.

Statistical summary of RF Fields on WTC roof (see Figure 8)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	23262	85 51
21-50	3937	14 47
51-100	6	0 02
>100	0	0 00

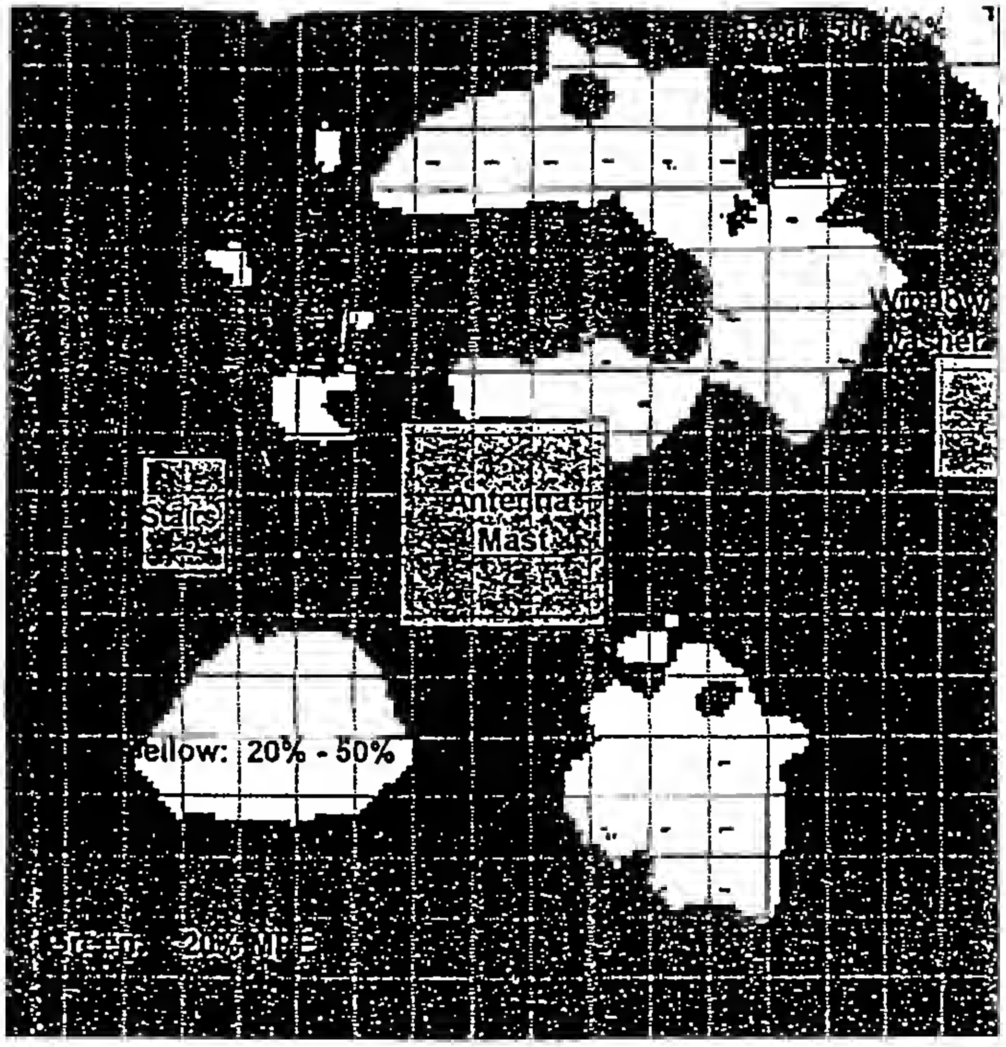


Figure 9. Roof map of RF fields during normal broadcast operations with calculated effect of raising 72 MHz paging links to 6 feet above roof No other wireless antennas active Maximum field is 57 2% MPE

Statistical summary of RF Fields on WTC roof (see Figure 9)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	21878	80 42
21-50	5318	19 55
51-100	9	0 03
>100	0	0 00

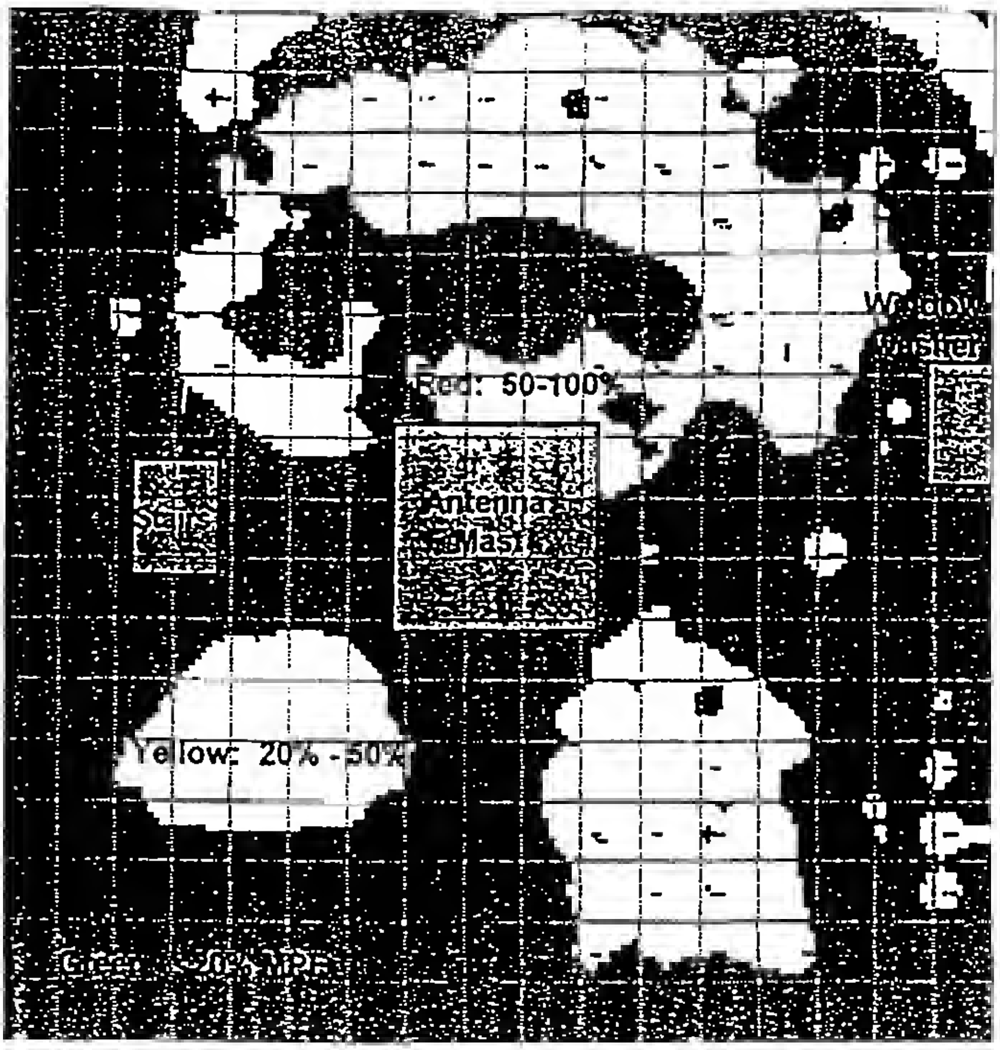


Figure 10. Roof map of RF fields during normal broadcasting operations with calculated effect of raising all wireless antennas to 6 feet above roof level. Maximum field is 67 2% MPE

Statistical summary of RF Fields on WTC roof (see Figure 10)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	18325	67.36
21-50	8794	32 32
51-100	86	0 32
>100	0	0 00

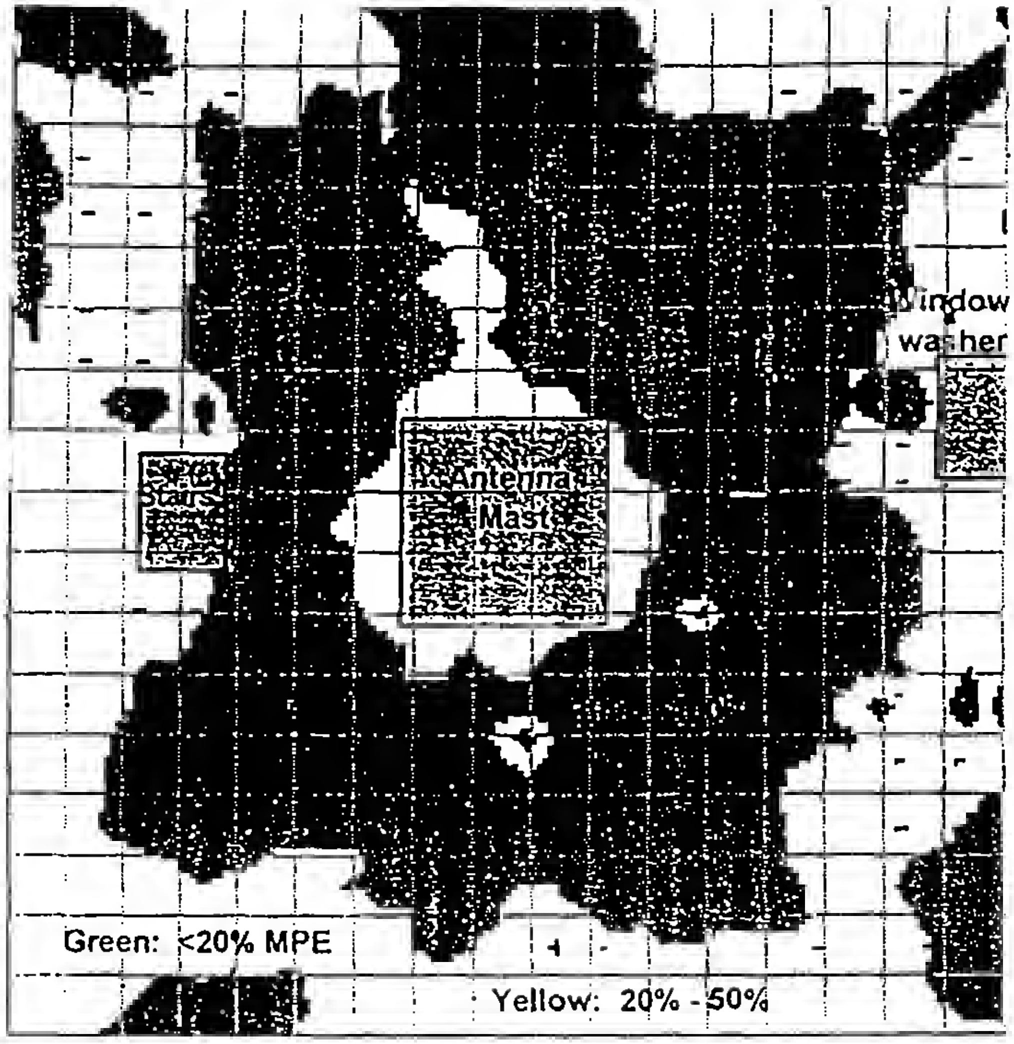


Figure 11. Roof map showing measured ambient RF fields on roof of north tower of World Trade Center during tower maintenance mode of broadcast operations with contributions from 72 MHz paging links included. Maximum field is 147.0% MPE.

Statistical summary of RF Fields on WTC roof (see Figure 11)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	1043	3.83
21-50	11728	43.11
51-100	13298	48.88
>100	1136	4.18

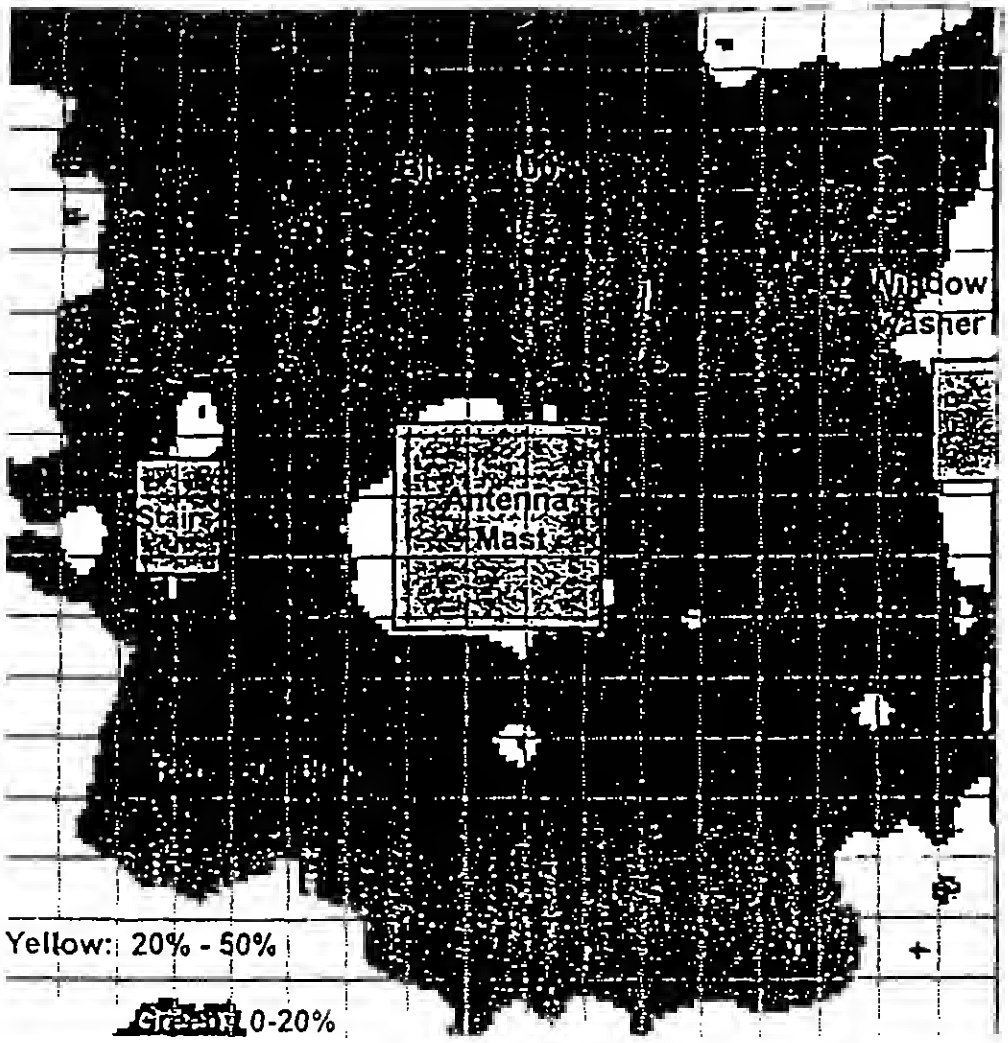


Figure 12. Roof map showing measured ambient RF fields on roof of north tower of World Trade Center during tower maintenance mode of broadcast operations with calculated contributions from all wireless telecommunications antennas included Maximum field is 352% MPE

Statistical summary of RF Fields on WTC roof (see Figure 12)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	130	0 48
21-50	5695	20.93
51-100	16891	62 09
>100	4489	16 50

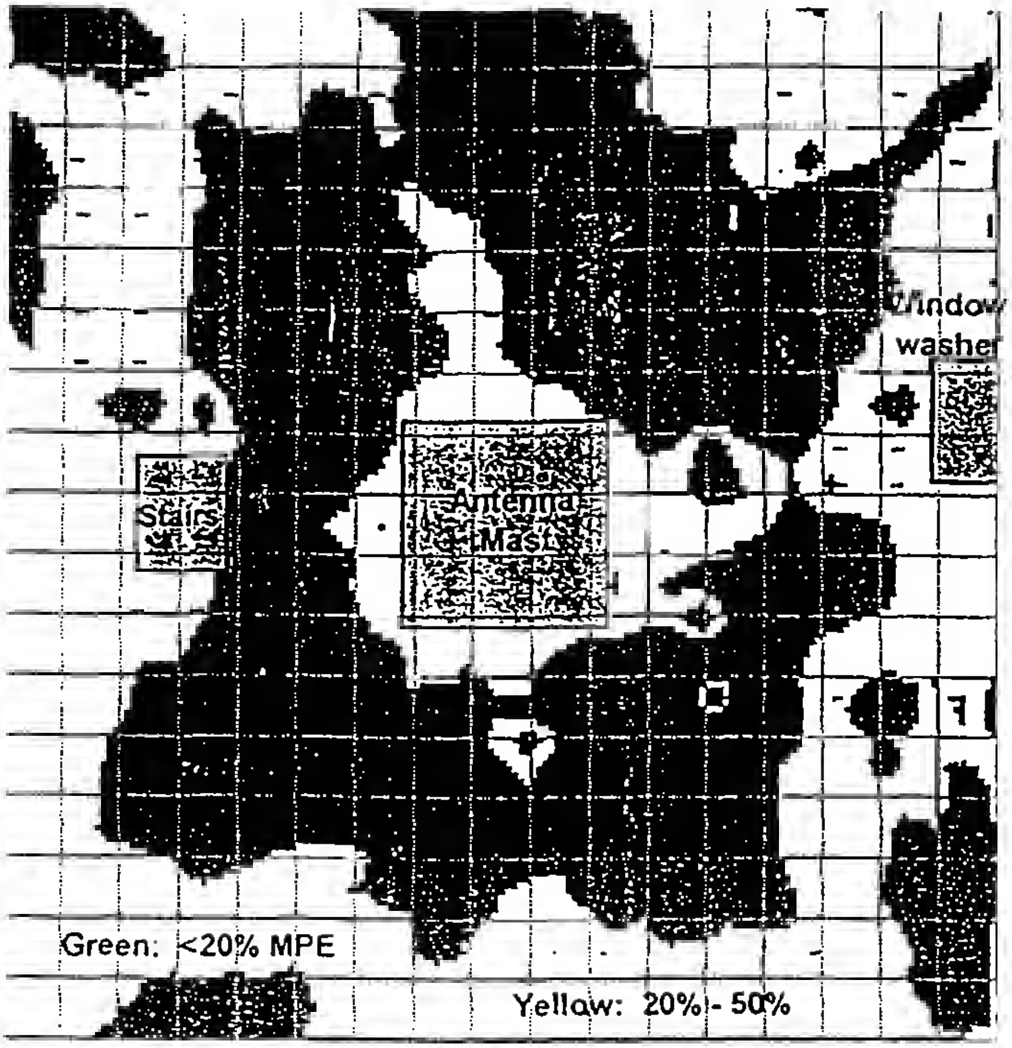


Figure 13. Roof map of RF fields during tower maintenance mode with contribution of 72 MHz paging links removed with RoofView Maximum field is 138.3% MPE

Statistical summary of RF Fields on WTC roof (see Figure 13)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	1546	5.68
21-50	13108	48.18
51-100	12035	44.24
>100	516	1.90

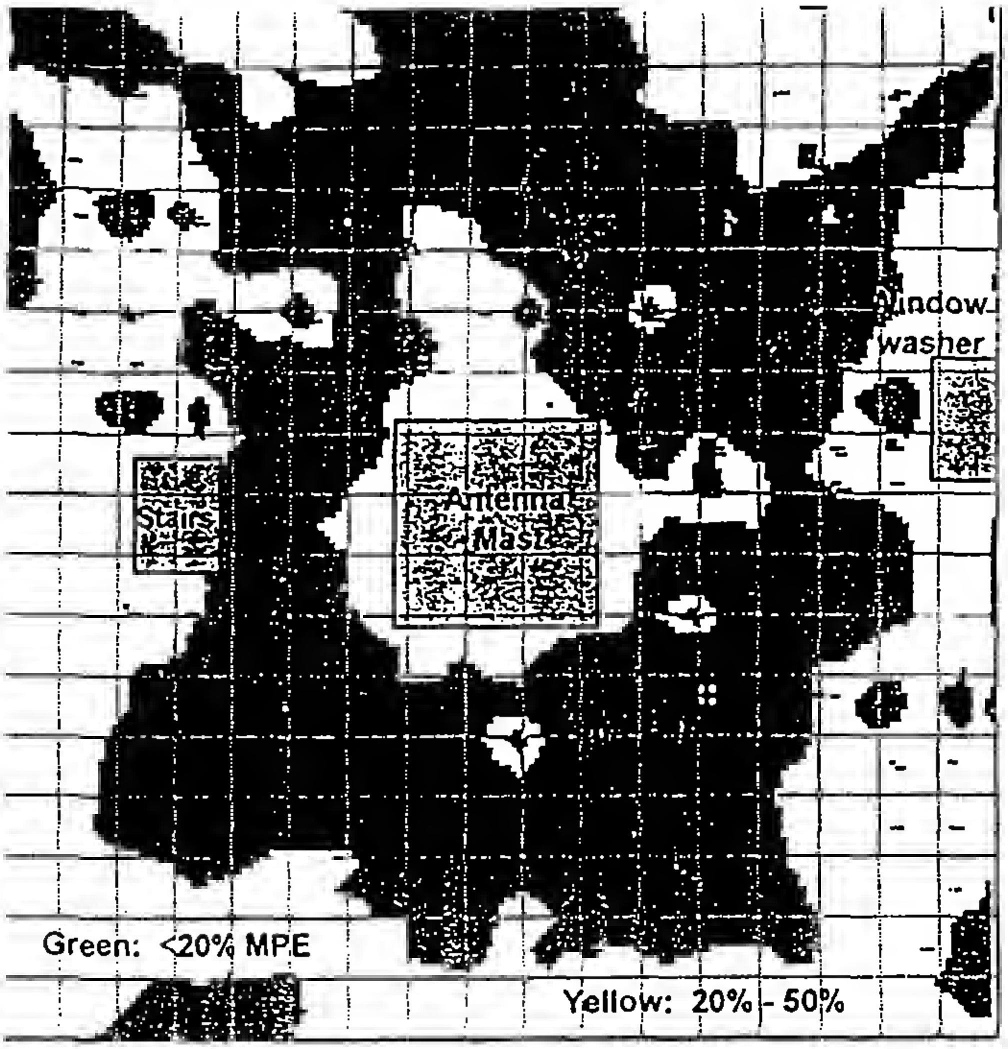


Figure 14. Roof map showing RF fields during broadcast tower maintenance mode with calculated effect of all wireless antennas raised to at least 6 feet above roof Maximum field is 144 3% MPE

Statistical summary of RF Fields on WTC roof (see Figure 14)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	992	3 65
21-50	12641	46.47
51-100	12879	47.34
>100	693	2 55

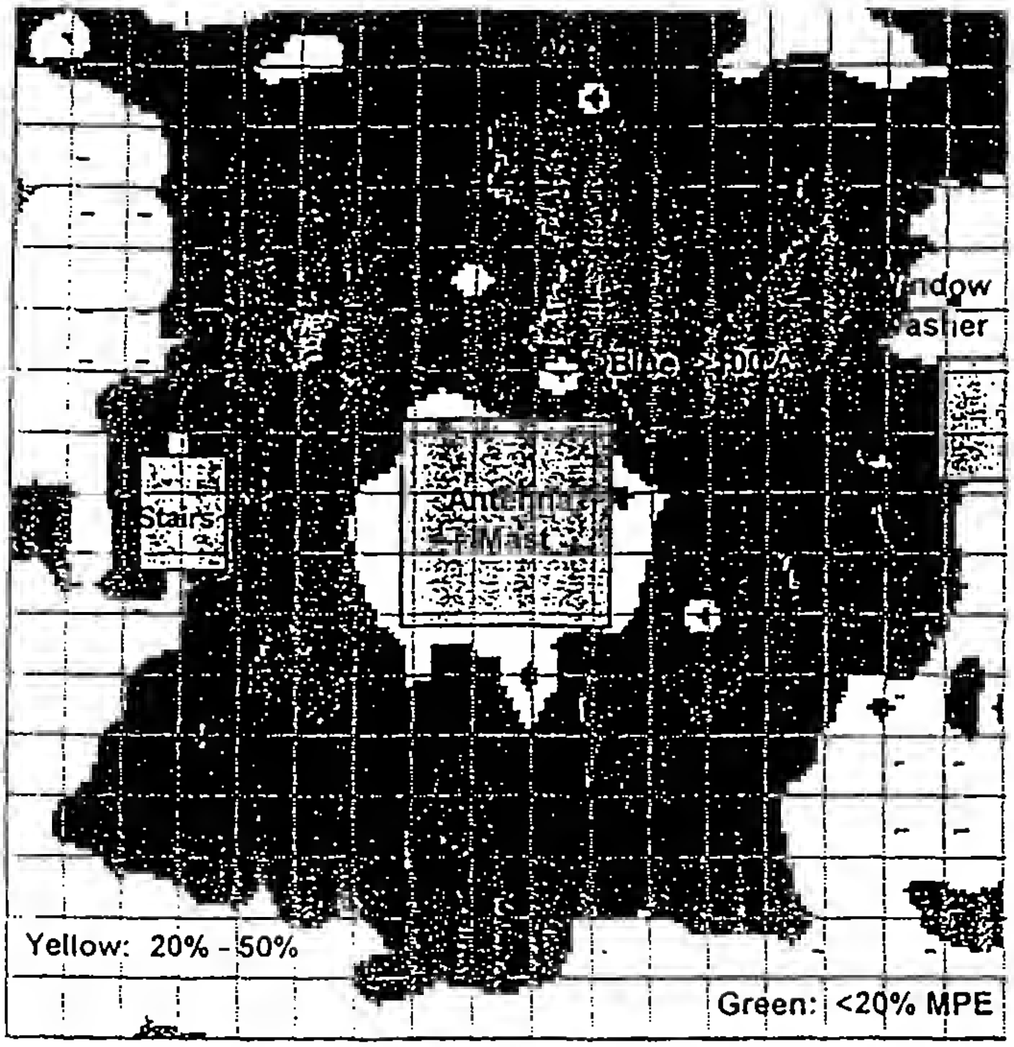


Figure 15. Roof map showing measured ambient RF fields on roof of north tower of World Trade Center during emergency backup broadcast operations with contributions from 72 MHz paging links included   Maximum field is 156 3% MPE

Statistical summary of RF Fields on WTC roof (see Figure 15)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	253	0 93
21-50	8677	31 89
51-100	15694	57 69
>100	2581	9 49

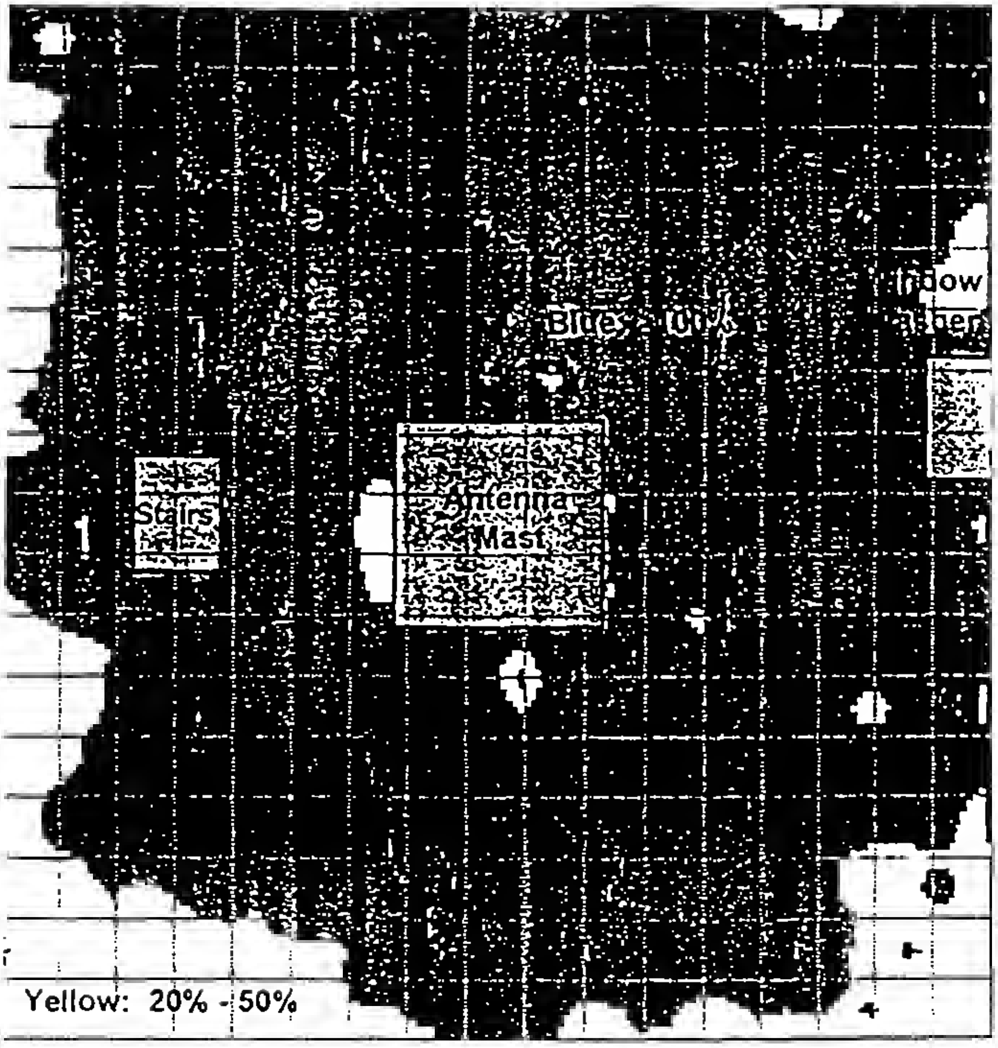


Figure 16. Roof map showing measured ambient RF fields on roof of north tower of World Trade Center during emergency backup broadcast operations with calculated maximum contributions from all wireless telecommunications antennas Maximum field is 373 0% MPE

Statistical summary of RF Fields on WTC roof (see Figure 16)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	3	0 01
21-50	3910	14 37
51-100	16016	58 87
>100	7276	26 75

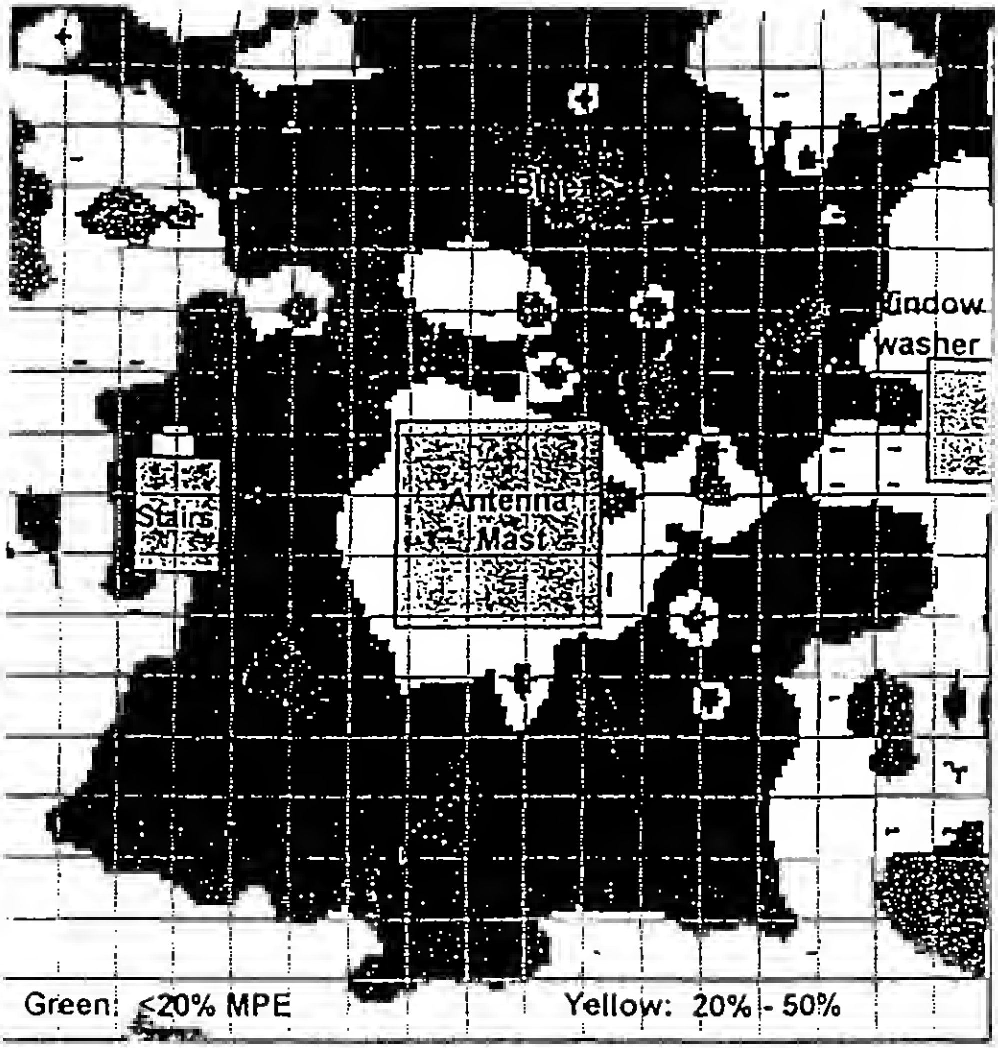


Figure 17. Roof map of emergency backup broadcast ambient RF fields with contribution of 72 MHz paging links removed via analysis with RoofView. Maximum field is 135.2% MPE

Statistical summary of RF Fields on WTC roof (see Figure 17)		
Percent occupational MPE range (%)	Roof area in this range (ft²)	Percent of roof area in this range (%)
0-20	1135	4.17
21-50	11034	40.56
51-100	14148	52.01
>100	888	3.26

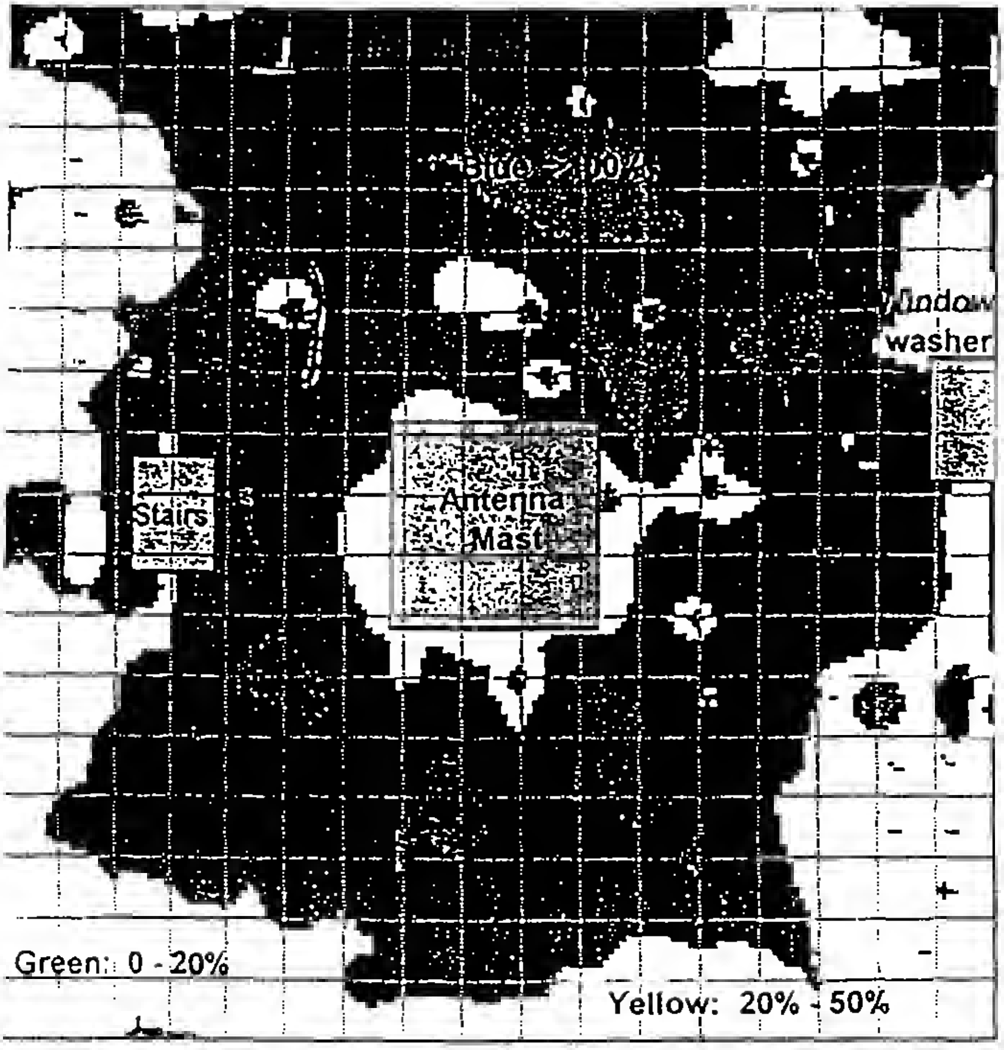


Figure 18. Roof map of RF fields during emergency broadcast backup operations with calculated effect of all wireless antennas raised at least 6 feet above roof level. Maximum field is 149.3% MPE

Statistical summary of RF Fields on WTC roof (see Figure 18)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	249	0.92
21-50	9104	33.46
51-100	16151	59.37
>100	1701	6.25

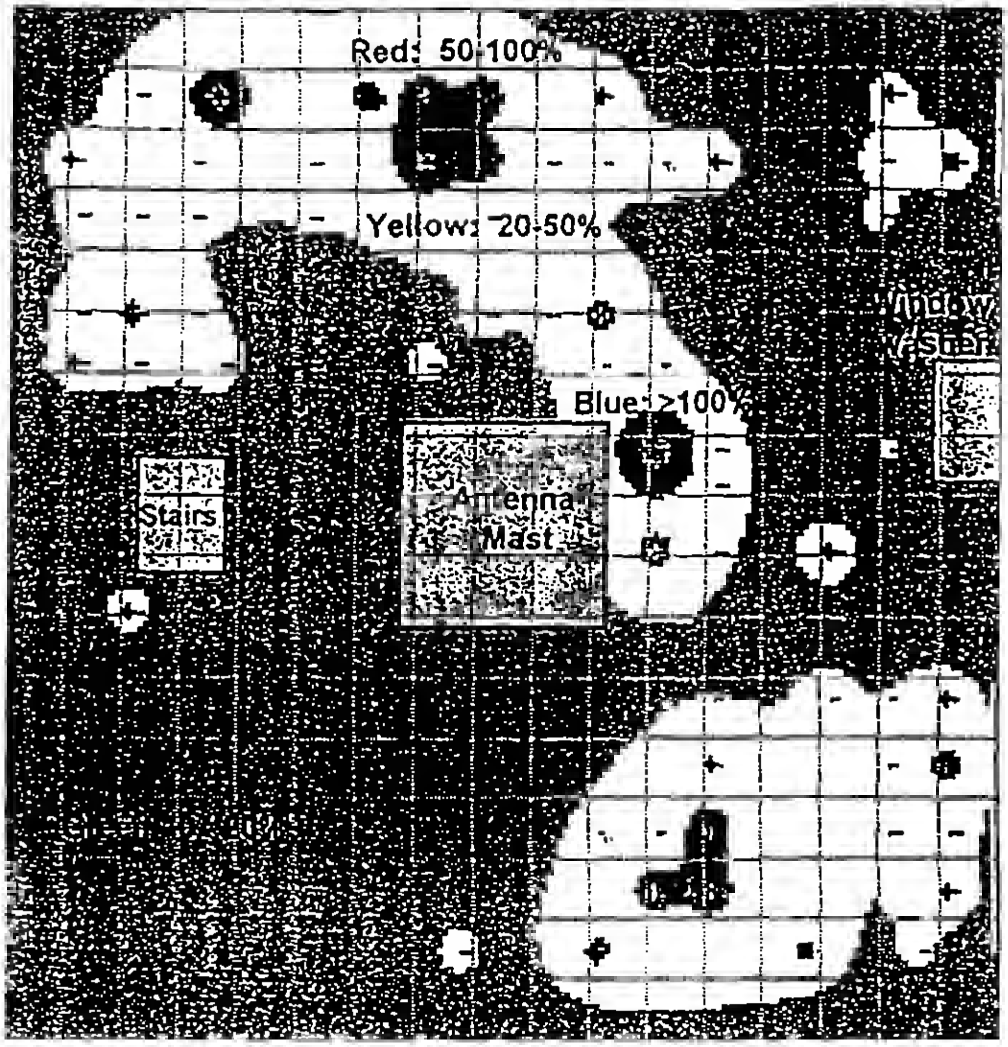


Figure 19. RoofView computed roof map for all wireless telecommunications antennas assumed operating but without contribution of RF fields from any of 72 MHz paging links or any contribution from broadcasting facilities Maximum field is 273 9% MPE

Statistical summary of RF Fields on WTC roof (see Figure 19)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	17324	63 68
21-50	8960	32.94
51-100	833	3.06
>100	88	0.32

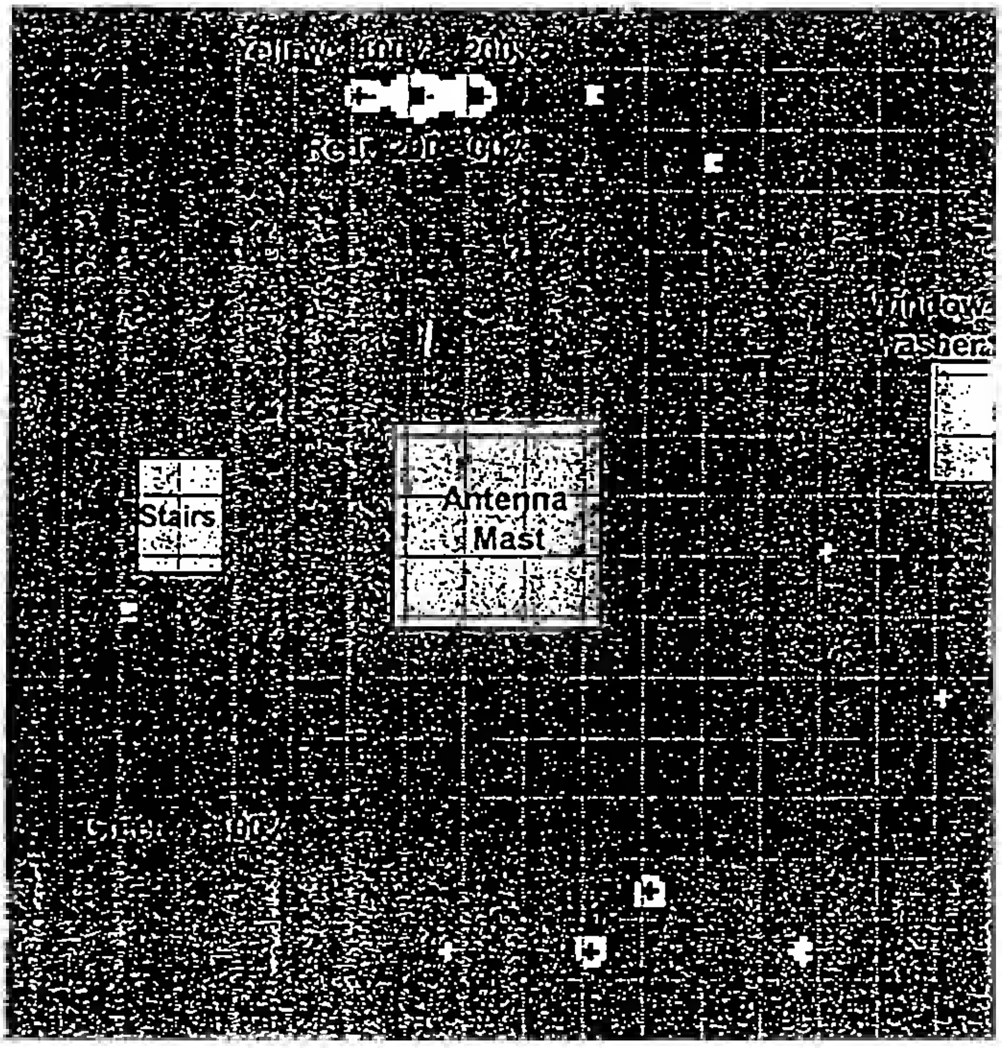


Figure 20. Roof map of calculated spatial peak RF fields from all wireless antennas only operating above 800 MHz. Maximum peak field is 276% MPE

Statistical summary of RF Fields on WTC roof (see Figure 20)		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-100	26956	99.08
101-200	216	0.79
201-300	33	0.12
>300	0	0.00

APPENDIX A-7

Additional RF Report, September 5, 1999

A Reevaluation of Radiofrequency Fields on the World Trade Center North Tower

A Supplemental Report

September 5, 1999
Revised March 21, 2000

Prepared for

Motorola
Land Mobile Products Sector

By

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A Reevaluation of Radiofrequency Fields on the World Trade Center North Tower

A Supplemental Report

Background

During June 1997, a comprehensive study of radiofrequency (RF) fields produced by both broadcast and wireless telecommunications antennas located on the roof of the World Trade Center (WTC) North Tower was completed.[1] That study was focussed on examining the aggregate RF fields at roof-level resulting from the normal operation of the various FM radio and VHF and UHF television broadcast stations. In addition, a tower maintenance mode of operation[2] that is used during times that personnel must climb the central antenna mast on the roof to conduct various maintenance activities was investigated. In the interim since that study, some communications transmitters were removed from operation. The purpose of this study was to reevaluate the expected RF field environment on the roof of the north tower under these two operating modes.

Review of the Method

The approach used in the initial study included measurement and analysis components. Measurement teams collected the field measurement data using isotropic, broadband, conformal electric field probes. Analysis was accomplished with a modified version of the RoofView® RF modeling program[3]. Detailed measurements of the RF fields resulting from broadcast transmitters were performed in a grid-like fashion on the roof during normal and tower maintenance modes of operation. These measurement data, collected at approximately five-foot intervals for a total of 889 measurement points, were then interpolated to arrive at estimates of field levels for every one foot of dimension on the roof. The measurement data were obtained with all wireless communications antennas turned off, except for several 72 MHz band paging link antennas. The contribution of the many wireless communications antennas to the RF environment was assessed by calculation, taking into account the location of each antenna and other technical information such as frequency, aperture height, mounting height and input power. The modified RoofView® program was used to combine the results of the extensive measurement data with the calculated results for the wireless antennas to arrive at an overall picture of the RF environment that would be expected to exist from the simultaneous operation of all transmitting equipment for both operating scenarios.

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[1] Tell, R. A. (1997) *An Evaluation of the Radiofrequency Environment at the World Trade Center North Tower*. Prepared by Richard Tell Associates, Inc. for Motorola, 53 p. September 29, 1997.

[2] During the tower maintenance mode of operation, UHF TV stations cease operation and VHF TV stations operate from much lower mounted auxillary antennas and channel 4 operates from the Empire State Building.

[3] RoofView® is a registered trademark of Richard Tell Associates, Inc.

Graphic representation of the composite RF field levels on the roof are depicted as a colorized map with various colors representing different ranges of RF field levels. For purposes of this reevaluation, the RF exposure limits prescribed in Federal Communications Commission (FCC) rules for occupational/controlled exposures were used[4]. Thresholds in the RoofView® program were set to obtain RF field ranges of 0 to 20% of the MPE, 21-50% of the MPE, 51-100% of the MPE and fields exceeding 100% of the MPE. The software automatically converts computed RF power densities into an equivalent percentage of the applicable MPE for each transmitter allowing convenient summing of the aggregate fields relative to the exposure limits.

Notes on Reevaluation Methodology

Prior to any subsequent analysis, the antenna and transmitter inventory at the WTC was once again studied by physically examining the roof-top and determining the number of transmitters combined on each antenna and their power levels. In this process, three-way antennas[5] were modeled as though they were three separate antennas having the same x-y coordinates on the roof but with different mounting heights. In the earlier study, these antennas were modeled as a single antenna having an overall vertical aperture height equal to the sum of the three separate apertures with a total power equal to the sum of the antenna input powers delivered to all three antennas. The antenna data used in this reevaluation are presented in Table 1. The inventory was obtained during March, 1999.

Another factor, relevant to the reevaluation, is that the RoofView® modeling software has been improved since the earlier study. The program now has the ability to more accurately model the spatially averaged fields as a function of aperture height and antenna mounting height. These changes, in addition to the changes in the number of active transmitters, will tend to introduce differences in the results. In some cases, these enhancements may result in higher computed fields while for certain conditions may result in lower computed fields for some antennas.

Reevaluation Results

The results of the new reevaluation are presented in Figures 1 and 3 for the normal and tower maintenance modes of operation of the broadcast stations respectively. For each figure, a chart beneath the roof field map summarizes the extent of the roof area, in terms of square footage and as a percent of the area. that is projected to have calculated, composite RF fields within the ranges described above. These figures provide a convenient way for envisioning the aggregate RF fields at each one square foot pixel on the roof. The roof area used in computing the percentages represents the total study area

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[4] The Maximum Permissible Exposure (MPE) represents a particular plane wave equivalent power density and is specified in the FCC rules according to frequency.

[5] A three-way antenna is an antenna containing three physically separate apertures located along the vertical axis of the antenna that can be separately driven with transmitters.

minus the areas associated with the stairwell, the central antenna mast area and the window washer equipment well (this amounts to a total area of 27,205 square feet).

These results, similar to those obtained in 1997, again show that only a very small portion of the roof, less than 1% (0.72%), is projected to have RF fields exceeding the MPE. One area located to the upper right of the central antenna mast area on the figures accounts for half of the total area potentially exceeding the MPE. This is due to the presence of wireless antennas but also a relatively intense background produced by the broadcast operations. The chart below summarizes the differences in roof areas subject to various RF field levels obtained in 1997 and the present reevaluation.

Summary of differences in WTC roof areas subject to different RF field levels obtained during 1997 study and 1999 reevaluation.

Normal broadcasting operations			
Percent MPE range (%)	Roof area in this range (ft^2) in 1997	Roof area in this range (ft^2) in 1999	Percent change in 1999 (%)
0-20	4502	5490	+21.9
21-50	16454	17508	+6.4
51-100	5963	4012	-32.7
>100	286	195	-31.8
Tower maintenance mode of operations			
Percent MPE range (%)	Roof area in this range (ft^2) in 1997	Roof area in this range (ft^2) in 1999	Percent change in 1999 (%)
0-20	130	194	+49.2
21-50	5695	6283	+10.3
51-100	16891	16948	+0.5
>100	4489	3780	-15.8

The present reevaluation indicates a reduction in the roof area that is subject to RF fields that may exceed the MPE limit. During normal broadcast operations, a projected 32% decrease in roof area above the MPE is obtained relative to the 1997 study. For the tower maintenance mode of broadcast operations, the area above the MPE is projected to decrease by 16%. The effect of this change results in the tendency of increasing the field levels in the lower power density ranges on the roof. The maximum RF field levels at a single point on the roof were found to only marginally reduce in value compared to the 1997 study (see figure captions for the maximum field anywhere on the roof).

Figure 1 was examined in considerable detail to determine what changes in antenna mounting heights would be required to reduce the calculated composite RF field levels to less than the MPE limit at all points on the roof. By using the RoofView® software in an interactive mode, individual hot spots shown on the roof were studied by increasing those antenna mounting heights in one foot increments and recalculating the entire roof until the area near the antenna no longer indicated a blue spot meaning that the composite fields were now below the 100% MPE threshold. Twenty-four antenna mount locations were analyzed to find alternative mounting heights that could reduce roof level fields below the MPE limit. These results are shown in Figure 2 and Table 2. Seven of the

eight three-way antennas were included in Table 2 indicating that low mounted, relatively high power apertures can lead to high RF fields on the roof, unless mounted sufficiently high above the roof. The right hand column in Table 2 shows the final mounting height determined by successive recalculation to bring the composite field below the MPE limit. A common finding during this phase of the work was that VHF band antennas, and especially those with high power, typically led to the areas exhibiting fields exceeding the MPE limit. It must again be emphasized, however, that the relatively high ambient background of RF fields produced by the broadcast stations exacerbates the issue and makes it more problematic to mitigate the roof level fields.

Conclusions

A reevaluation of the RF environment on the roof of the WTC north tower, using improved software analysis, and based on a new inventory of active antennas on the roof in 1999, shows a modest reduction in the area on the roof subject to RF fields potentially in excess of the FCC MPE limit for occupational/controlled exposures. For the normal broadcasting mode of operation, a total of 195 square feet of the roof could be expected to possibly exceed the FCC MPE limit. It is important to emphasize that these calculated results are based on an assumption that all wireless telecommunications antennas on the roof are simultaneously active; this is likely not the case most of the time. Under normal broadcasting conditions, complying with the site guideline of maintaining a minimum clearance of 3 feet from all antennas will likely suffice to control personnel exposures, most of the time. This is not the case for the tower maintenance mode of operation because of the much more intense background of RF fields produced by the lower mounted auxiliary broadcast antennas. During tower maintenance mode of operation, access to the roof should be carefully controlled with due attention paid to the roof field maps for guidance on areas of suspected maximum field levels. The use of personal RF monitors during work on the roof can provide an additional safeguard against excessive exposure and help insure compliance with FCC exposure rules.

Elevating certain antennas on the roof will tend to reduce local fields in the near vicinity of those antennas. While this approach to roof level field mitigation can be effective, personnel training in RF safety issues, the use of personal RF monitors and instigation of specific work practices may prove as effective, and more practical, for insuring compliance with FCC RF exposure rules.

Table 1. Antenna data table used for reanalysis of WTC roof.

Ch	ID	Name	Freq	Trans Power	Freq Code	Cable Type	Cable Length		Gain			X	Y	Z	
3 NG	Cent	875(0000)	1610	1	100 7/8"	75		0[illegible]				79.0	12[illegible]	3[illegible]	14
3 NG	Cent	8850000	1510	1	100 7/8"	75		91.0				79.0	12[illegible]	74	14
4 NG	Cent	8850000	1510	1	100 7/8"	75		91.0				79.0	12[illegible]	00	14
5 M	Cent	8250000	1610	1	100 7/8"	75		91.0				12.4	12[illegible]	70	14
6 M	Cent	8350000	1610	1	100 7/8"	74		81.0				10.5	12[illegible]	74	14
7 M	Cent	8350000	1510	1	100 7/8"	75		81.0				10.5	[illegible]	85	14
8 ML	Cent	8450000	1510	1	100 7/8"	75		90.0				11.5	12[illegible]	60	14
9 ML	Cent	8250000	1510	1	100 7/8"	75		90.0				10.5	12[illegible]	44	14
10 ML	Cent	8250000	1510	1	100 7/8"	75		90.0				10.5	12[illegible]	36	14
11 MM	[illegible]	1630000	750		100 7/8"	66		66.2				106.5	12[illegible]	36	20.0
12 [illegible]	Cent	8250000	1610	1	100 7/8"	75		73.4				11.5	25[illegible]	70	14
13 [illegible]	Cent	8350000	1510	1	100 7/8"	75		37.4				11.5	25[illegible]	74	14

Table 2. Summary of calculated antenna-mounting heights* to achieve RF fields less than MPE.		
Antenna	Old mount heights (ft)	New mount heights (ft)
2, 3, 4	3, 7.4, 8.8	4, 8.4, 9.8
5, 6, 7	3, 7.4, 8.8	5, 9.4, 10.8
12, 13, 14	3, 7.4, 8.8	5, 9.4, 10.8
15	3	6
16	5.5	6.5
19	3	6
22	3	4
24	3	5
27	2.5	4
30	3	6
34	2	8
39	2.5	6
47	4.5	6.5
52	2	4
60	2.5	4.5
63	2	5
66, 67	9, 5	10, 6
72	5	7
73, 74, 75	2.5, 6.9, 11.3	4.5, 8.9, 13.3
76,77,78	2.5, 6.9, 11.3	5.5, 9.9, 14.3
79, 80, 81	2.5, 6.9, 11.3	4.5, 8.9, 13.3
82, 83, 84	2.5, 6.9, 11.3	4.5, 8.9, 13.3
86	4	8
93	3	5

*Antenna mounting height is the height above the surface of the roof to the <u>bottom</u> of the active antenna aperture.

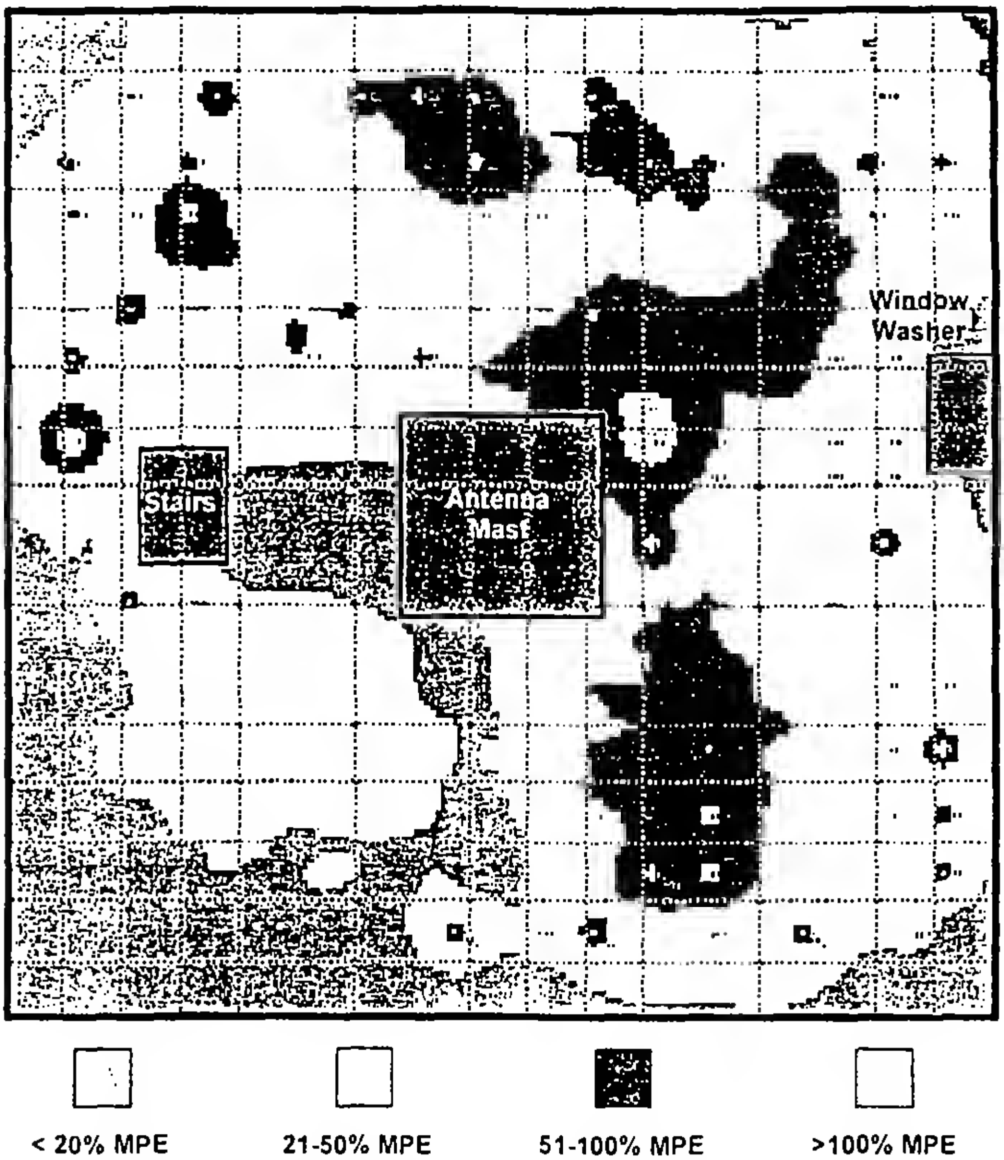


Figure 1. 1999 reevaluation of RF fields from measured ambient fields of normal broadcasting operations with calculated contribution of all wireless telecommunications antennas. Maximum field is 299.6% MPE.

1999 Statistical summary of RF Fields on WTC roof		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	5490	20.18
21-50	17508	64.36
51-100	4012	14.75
>100	195	0.72

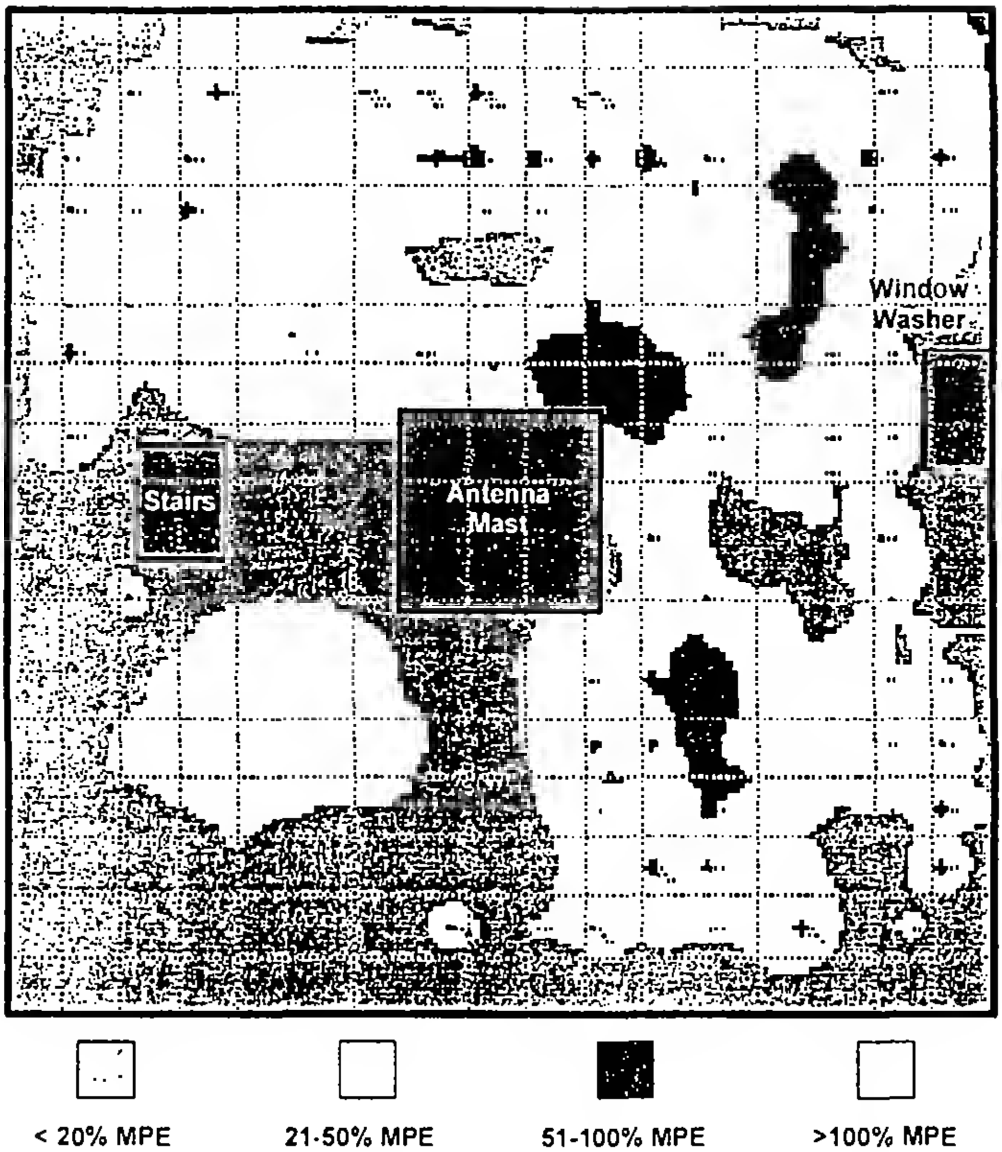


Figure 2. 1999 reevaluation of RF fields from measured ambient fields of normal broadcasting operations with calculated contribution of all wireless telecommunications antennas with selected antennas raised to eliminate fields exceeding MPE. Maximum field is 77.5% MPE.

1999 Statistical summary of RF Fields on WTC roof		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	9810	36.06
21-50	16232	59.67
51-100	1163	4.27
>100	0	0.00

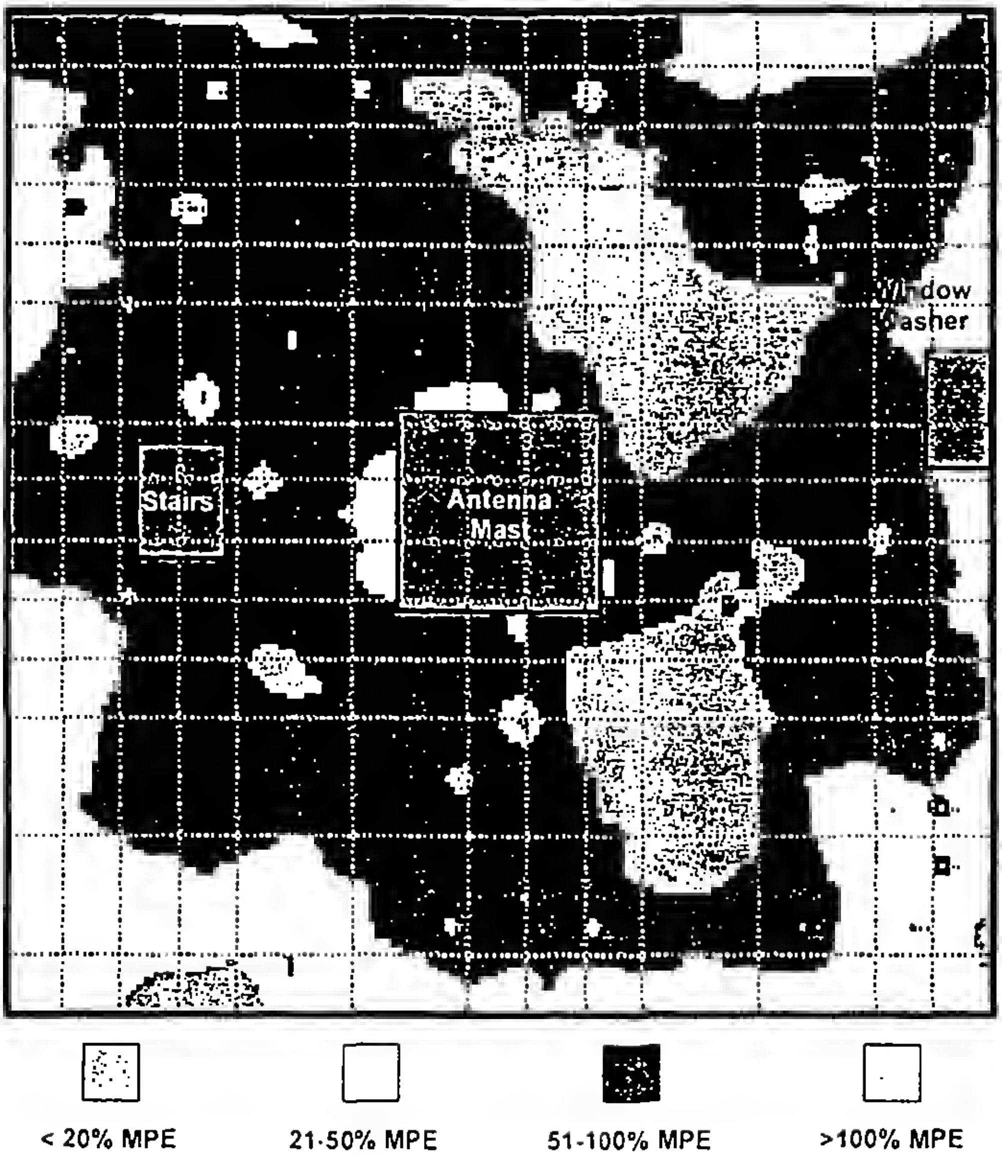


Figure 3. 1999 reanalysis of RF fields from measured ambient fields of tower maintenance broadcasting operations with calculated contribution of all wireless telecommunications antennas. Maximum field is 333.5% MPE.

1999 Statistical summary of RF Fields on WTC roof		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	194	0.71
21-50	6283	23.10
51-100	16948	62.3
>100	3780	13.89

APPENDIX A-8

Memorandum 1/27/2000 Regarding
Radiation Safety Survey, One WTC

THE PORT AUTHORITY OF NY & NJ MEMORANDUM

TO: George Tabeek, Project Manager
FROM: Paul W. Mitchell
DATE: January 27, 2000
SUBJECT: RADIATION SAFETY SURVEY - ONE WORLD TRADE CENTER

COPY TO: N. Chanfrau, D. Karpiloff, M. Plaskon, P. Taylor, G. Wojnar

On December 21, 1999, George DeFreese of my staff conducted the semi-annual Radiation Safety Survey of the Barringer IONSCAN 400 Ion Mobility Spectrometer located in the lobby of 1 WTC. Possession and use of the instrument is in compliance with the conditions of the general license. The instrument's New York State Department of Labor registration number is X-14101.

The survey included an inspection of the storage area and of the instrument, and leak test sampling. The results of the survey are attached. Leak test sampling of the instrument was performed in order to detect removable (leaking) radioactive material from the Nickel 63 sealed source unit. The sample was submitted to Monitoring Services for analysis and the result was found to be acceptable. A copy of the report is attached for your records. A copy of the current leak testing result (not older than six months) must accompany the instrument whenever it is transported.

The next radiation safety survey will be conducted in June, 2000.

If you have any questions about this survey or require information regarding radiation safety, please call me at (201) 216-2173.

Paul W Mitchell

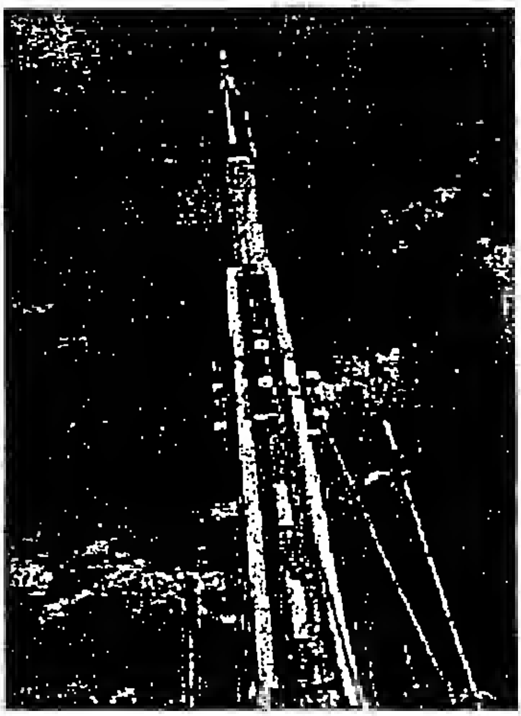
Paul W. Mitchell, CIH
Manager
Occupational Health
Inspection and Safety Division

Attachments

APPENDIX A-9

Richard Tell Associates, Inc., May 12, 2000,
"An Investigation of RF Safety Considerations on the WTC Antenna Mast Relevant to Work to Install a New Digital Television Antenna."

An Investigation of RF Safety Considerations on the World Trade Center Antenna Mast Relevant to Work to Install a New Digital Television Antenna



May 12, 2000

Prepared for

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By

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Acknowledgments

A number of individuals provided support during the RF field measurements documented in this report and they are hereby acknowledged for their assistance. They include:

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An Investigation of RF Safety Considerations on the World Trade Center Antenna Mast Relevant to Work to Install a New Digital Television Antenna

Table of Contents

An Investigation of RF Safety Considerations on the World Trade Center Antenna Mast Relevant to Work to Install a New Digital Television Antenna

Introduction

New York City television (TV) broadcasters at the World Trade Center (WTC) are preparing to augment their present services with high definition, or digital, TV (DTV) transmissions. This new capability will require the installation of a new master antenna that will be used by those stations electing to add DTV service to be located within a presently unused area on the existing antenna mast at the WTC north tower. A UHF antennas, formerly used by channel 41, located just above the auxiliary antenna for channels four and five, is proposed to be disassembled and removed to provide space for a new UHF master TV antenna. The process of disassembly and removal of the old channel 41 antenna and installation of the new antenna will require considerable effort and workers will necessarily have to be located in areas with potentially intense RF fields. The purpose of the work documented in this report was to characterize the RF field environment in the region of the mast to be occupied by mast workers and to use the measurements to develop a suitable set of procedures to ensure that RF exposure of all workers will comply with regulations set by the Federal Communications Commission (FCC). This report describes the process by which RF field measurements were taken in the designated work region and provides insights and recommendations that will assist in complying with the FCC rules.

The FCC RF Maximum Permissible Exposure Limits

During the antenna change out project, individuals working at the WTC rooftop site will be subject to RF fields due to a combination of both broadcast transmissions and a proliferation of wireless telecommunications antennas mounted on the roof. The roof of the north tower of the WTC is a controlled environment, as defined in the WTC RF Safety Program documentation[1]. This means that the applicable maximum permissible exposure (MPE) limit is that designated by the FCC for occupational/controlled exposure. Appendix A contains details on the FCC MPE limits. Controls are in place to restrict access to the rooftop to personnel who have been trained in RF safety matters or who are escorted by someone who has been so trained. In addition, special procedures are in place for tower maintenance activities to prevent exposure to RF fields that would exceed the occupational/controlled MPE limit.

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[1] World Trade Center North Tower Roof RF Safety Program prepared by Richard Tell Associates, Inc. for the Port Authority of New York and New Jersey, World Trade Center, February 1, 1999.

Recent RF Safety Related Work at the World Trade Center

A number of relatively recent activities have taken place at the WTC in the past that have been related to RF safety. These include:

1. In 1998, a comprehensive RF safety program was documented and serves as the guidance document for matters related to RF safety considerations the WTC.
2. In 1997, a comprehensive study of roof-level RF fields was undertaken on the roof of the WTC north tower[2]. This study provided details on the distribution and magnitude of the composite RF fields produced by the combined effect of all broadcast stations and the roof-mounted wireless communications antennas. An output of this exercise was the generation of colorized roof field maps showing those areas with more intense fields and those with weaker fields. These maps could be used by personnel working on the roof to identify areas to avoid due to RF fields that might exceed the FCC exposure limits.
3. In 1999, an update of the 1997 study was prepared that took into account changes in the many wireless communications transmitters at the WTC. That project resulted in updated, colorized roof field maps as described in 2 above.
4. In addition, in 1999, a study of ambient RF fields on the public walkway located on the WTC south tower building was completed. The purpose of that study was to examine the magnitude of RF fields produced by the operations on the north tower with an emphasis on whether such fields might exceed the more stringent, general public MPE limit (see Appendix A for details on the differences between the occupational/controlled and general public/uncontrolled MPE limits). That study determined that RF fields on the walkway comply with the general public MPE limit.

Technical Approach to Evaluation of RF fields.

Attempting to perform meaningful RF field measurements at awkward points substantially elevated above the roof of the WTC north tower Is problematic. After examining the proposed work activities that would be accomplished during the DTV antenna project, it was concluded that the most useful assessment of potential exposure of workers would be accomplished through a series of RF field measurements made parallel to the antenna mast. If a field measurement probe could be positioned adjacent to the mast, but close to it, the magnitude of the measured RF fields would most likely approximate the RF field exposure environment that workers could access. Proper positioning of a field probe, however, would be challenging considering the overall height of the defined work area throughout which measurements would be necessary to properly characterize the fields and the almost ever-present and disagreeable winds aloft at the top of the WTC.

The measurement approach ultimately selected consisted of rigging the antenna mast with nylon ropes to permit the raising and lowering of an electric field strength

[2] An Evaluation of the Radiofrequency Environment at the World Trade Center North Tower prepared by Richard Tell Associates, Inc. for Motorola Network Services Division, September 25, 1997.

probe from nominally roof level to the height of an ice shield located at the top of the channel 47 antenna aperture. This would allow field probing of the primary work area which would extend from the bottom of the channel 41 antenna aperture to the top of the channel 47 aperture. While workers would not occupy the region directly in front of the master FM antenna while it was active, nonetheless, any field measurement data that could be collected in this region as well was deemed as potentially useful to provide perspective on the relative magnitude of RF fields to which workers could be exposed if appropriate procedures were not followed. The principal work area during the antenna project, where personnel will be located, will be nominally between 101 feet and 175 feet above the roof. The main work area is the nominal 74 feet of vertical aperture extending from the bottom of the channel 41 to the top of the channel 47 apertures.

In concept, the antenna mast was to be rigged with ropes similar to that illustrated in Figure 1, with pulleys being installed at the ice shield on all four sides of the mast to accommodate a succession of four separate sets of RF field measurements along each of the four sides of the mast. Figure 2 is a telephoto shot showing attachment of the nylon ropes at the ice shield. A fourth pulley, on the opposite side of the mast, cannot be seen in Figure 2. These ropes were temporarily anchored near the edge of the roof until the actual measurement process at which time the ropes were brought into near the base of the mast, passed through a second pulley and tied together. Using heavy nylon straps, the bottom pulley was then securely anchored to the bottom level of the surrounding "grand stand" and tightened such that the ropes were parallel and exhibited the least practical degree of bow due to the wind loading on the ropes. Figure 3 is a photograph showing the tower as it was rigged and identifies important points on the mast relative to the field measurement project. A field crew of tower riggers was present to handle the ropes during the measurements.

Field measurements were conducted on two occasions at the WTC, during the early morning hours of April 6 and May 1, 2000. The first set of measurements resulted in the eventual collection of field data on all four sides of the antenna mast, despite the issue of high winds that made the process rather difficult. For example, with the strong winds, the field probe that was attached to the ropes had relatively substantial movement about the axis of the unperturbed rope in the absence of wind gusts. This oscillation of the probe's lateral distance from the unperturbed rope axis was potentially most significant while the probe transited the region of the FM master antenna as, in this area, the probe was blown back and forth such that it came close to the FM elements at moments and this could lead to momentary pulse-like appearing excursions of electric field strength. At the time of the second set of measurements, the winds atop the WTC were even stronger than on the first occasion and, effectively, limited measurement options to only the south side of the mast, this being on the leeward side of the mast. During the second set of measurements, though, on this one measured side of the mast, the probe appeared to be notably more stable than in the previous measurements except at the height corresponding approximately to the height of the master FM antenna.

During the field measurement process, the auxiliary antennas located beneath the bottom of the channel 41 aperture were locked out so that they could not be used. This

was done to keep roof level RF fields near the base of the mast less than the MPE limit for occupational/controlled exposures. During the first set of measurements on April 6. all stations operated in their normal mode except for channel 47. which ceased operation for the entirety of the night of measurements. which began just after 1:00 a.m. Because of channel 47's normal high power operation. 4,570 kW peak visual effective radiated power (ERP). is likely to cause excessively intense RF fields in the region immediately below it where workers will need access. Hence. during actual work on the DTV antenna project. channel 47 would operate at substantially reduced power from a temporary antenna mounted on a mast some 48.5 feet from the center of the mast at a height of about 37 feet above the roof.[3]

During the second set of measurements. field measurements were performed with all four FM stations that normally operate from the FM master antenna turned off as well as several other scenarios. Channel 47. again. ceased operation for the duration of the mast measurements.

The field measurement process involved measurement of the electric field strength as a function of height parallel to the WTC antenna mast. Typically. the measurements consisted of monitoring and recording the electric field strength in two runs. one while raising the probe and another while lowering the probe. A difference between the two measurement sessions is that during the first one. the probe was raised approximately 3-4 feet at a time and allowed to dwell at that height for approximately 10-12 seconds. during which time the field probe sampled the field at a rate of two readings per second. This approach allowed for a better indication of the average field value at each height due to the wind-induced motion of the probe relative to the mast. During the second set of measurements. an alternative rigging arrangement was used wherein the rope at the bottom of the mast was separated several feet with a third pulley and this helped prevent rotation of the ropes due to the wind. This also permitted the use of a slow and continual raising of the probe in both the upward and downward directions. providing a more continuous and smooth measurement data set. Electric field strength was measured at the rate of two readings per second at all times. Field readings were correlated with various heights on the mast by one observer watching the probe from near the edge of the roof as it was moved up or down by the mast and communicating to a person operating the computer data acquisition when the probe was adjacent to or passing by specific key points on the mast. The computer operator noted these moments by recording the time from the computer's real time clock. These recorded times then allowed for analysis of the saved data within specific regions along the mast by referencing to the correlated times. Figure 4 shows the probe as it passed by one of the FM master antenna elements.

Electric field strength readings were in terms of the resultant field obtained from an isotropic field probe with three separate. orthogonal sensors. In the first set of measurements. the resultant electric field strength was directly plotted vs. time as the

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[3] Tell. R. A (2000) Analysis of Radiofrequency Fields from the Proposed Use of a Standby Antenna by WNJU TV (Channel 47) at the World Trade Center. Prepared for WNJU TV New York Telemundo Station Group by Richard Tell Associates. Inc.. February 17.

indicator of fields parallel to the mast. In the second set of measurements, the resultant electric field strength readings were used to compute the plane wave equivalent power densities and these values were plotted vs. time for comparison with the MPE limits. Plane wave equivalent power density (S) was calculated from the following relationship:

$$S = \frac{E^2}{3770}(mW/cm^2)$$

where, E is the electric field strength in volts per meter and the factor 3,770 accounts for the impedance of free space and converts to units of milliwatts per square centimeter.

Instrumentation

The availability of a new broadband, isotropic electric field probe manufactured by Holaday Industries, Inc.[4] presented the possibility of measuring the RF field parallel to the antenna mast and observing, in real time, the value of the RF field at a convenient location on the roof. This capability is provided through a fiber optic cable that connects with the probe and a computer equipped with a fiber optic to RS-232 modem and running Holaday Industries' ProbeView™ software. The probe, shown in Figure 5, consists of three mutually orthogonal sensors mounted to the exterior of an approximate one-inch cube housing and transmits field strength data via a fiber optic cable pair to either a digital meter or directly into a computer. An internal miniature battery gives the probe a continuous operating time of 10 hours before needing to be recharged. For these measurements, the direct computer data acquisition method was used as it allows higher reading rates. Specifications for the HI-6005 probe are given in Appendix B. Different units were used on the two measurement dates and calibration data for the specific probes used are given in Figure 6. Of significance is the observation that the error associated with field readings, determined at the factory, was no more than 2%. Figure 7 illustrates the representative linearity data for the probe used during the first set of measurements and shows that over the electric field strength range of 0.5 V/m to 900 V/m, it deviates no more than 1%. These are relatively remarkable specifications for these types of measurements and help minimize the uncertainty in the final results due to instrumentation characteristics.

The probe was placed inside a small canvas bag, which was, in turn, attached to the rope for elevation along the mast on the first measurement date. For the second set of measurements, the probe was placed inside a protective Styrofoam shell as shown in Figure 8. The two hemispherical Styrofoam shells were fastened together with Velcro strips and the entire assembly was then taped to one of the ropes rigged to the mast. Data was read out through the ProbeView™ software as viewed on the screen of a laptop computer used on-site during the measurement process. Figure 9 provides a view of the appearance of the laptop screen and shows that each individual polarization component magnitude as well as the resultant field magnitude is displayed in real time. A time series

[4] Holaday Industries, Inc., 14825 Martin Drive, Eden Prairie, MN 55344 (telephone: 612-934-4920 X115) <www.holadayinc.com>. Model HI-6005 electric field probe.

chart is also displayed to permit visualization of the acquired data as the probe was moved up or down the mast. Upon each run of the probe, a data file was saved to the hard drive of the computer representing the measured values for each polarization component and the resultant magnitude. These files were then analyzed with a spread sheet program following the data collection and the data were used to prepare graphical plots of the measured field strengths expressed in volts per meter (V/m) or derived plane wave equivalent power densities expressed in milliwatts per square centimeter (mW/cm^2).

An important issue relative to this evaluation is that while the applicable exposure limits are frequency dependent, the measurement probe used has a flat response over the entire range of importance at the WTC. This difference can be addressed as follows. First, all fields measured were referenced to the MPE limit applicable in the VHF portion of the spectrum where the limit is most stringent, i.e., where the MPE limit is equivalent to a power density of 1 mW/cm^2, even though there may be RF energy present above the 30-300 MHz frequency range and at which the MPE limit is less stringent. This approach would be conservative in that any field contributions above 300 MHz would be evaluated as though they were actually in the 30-300 MHz band. Secondly, it would not be anticipated that the RF fields in the regions measured would be significantly affected by UHF energy due to the fact that the probe measurement path never placed the probe in front of any UHF TV antennas and the elevation plane directivity of the channel 31 antenna is such as to significantly reduce downward directed energy into the measurement path. Based on these observations, it was deemed that use of the flat responding Holaday Industries field probe would not lead to any significant uncertainty in the field readings relative to a conservative assessment of compliance with the MPE limits. It is relevant to point out that the Model HI-6005 probe does make use of diode sensors and that the measurement system is designed to correct probe sensor outputs for their possible deviation from true square law response, for example, when the fields are intense enough to drive the diode out of its square law performance region of operation. While this method provides highly accurate results for singular frequency RF field measurements, the square law correction method used can, for very strong and approximately equal strength RF fields on different frequencies, result in over-indication of the resultant RF field strength. This phenomenon is the result of multiple frequency RF fields adding together in phase and leading to a given diode output voltage that will be corrected for square law response as though the diode sensor output is due to a single frequency field. This process can result in an overstatement of the actual field. In summary, use of the HI-6005 probe was believed to represent the overall best instrumentation for the task resulting in data with the least overall uncertainty, considering the inherent problems of correlating measured fields with specific heights on the mast. At the same time, any error resulting from use of this probe, if any, would generally lead to conservative determinations of field levels from a safety perspective, indicating somewhat stronger fields relative to MPE limits than might actually exist at a point.

Measurement Results

April 6, 2000 - Processed electric field strength data are presented for the four sides (North through West) of the antenna mast in Figures 10-17. For each side of the mast, data are provided for both the up and down movement of the probe. Figure 10 illustrates measured fields on the north side of the mast for the upward path of the probe. As the probe passes through the aperture region of the FM master antenna, very strong fields were found. Figure 10 plots the data, however, only for the work region extending from the bottom of the channel 41 aperture to the top of the channel 47 aperture. RF fields exceeding the electric field strength limit of 61 V/m (equivalent to a power density of 1 mW/cm^2) are indicated throughout a large portion of the channel 41 aperture. These peak electric field strengths correspond to a maximum plane wave equivalent power density of 2.8 mW/cm^2. The upper half of the channel 41 aperture and throughout the channel 47 aperture, the RF fields are substantially reduced. Similar plots of the electric field strengths are found in the remaining figures 11-17 and demonstrate a similar character with RF fields being greatest near the bottom of the channel 41 aperture. Figure 12 is a plot of measured fields that included the FM master antenna region and clearly shows the extremely elevated fields near the FM antenna. These fields decrease very quickly both below and above the master FM antenna. Nonetheless, RF fields exceeding 1 mW/cm^2 are commonly found near the bottom of the work area. The remaining figures illustrate similar results and can summarized by the observation that RF fields above the FM master antenna, but within the work area, have the potential of exceeding the FCC MPE limits somewhat. An anomaly in Figure 13 is represented by a spike in the plotted values of electric field strength near the bottom of the channel 41 aperture. It is not clear just what may have led to this reported value. One hypothesis is that the elevated fields near the bottom of the channel 41 area may be caused by reradiation by the auxiliary antennas for channels 4 and 5 of fields produced by the master FM antenna. Clearly, the relatively strong fields produced by the master FM antenna have the potential for illuminating the adjacently mounted auxiliary antennas and, hence, the presence of reradiated and scattered fields in that vicinity.

The various measurements obtained for the work area on April 6, are summarized in the chart below.

Summary of RF field measurement data obtained April 6, 2000 in WTC antenna mast work area.

Side of mast	Power density up (mW/cm^2)	Power density down (mW/cm^2)
North	3.0	2.8
East	77	1.1
South	0.42	1.3
West	0.56	1.3

The single very high value of 77 mW/cm^2 recorded on the east side of the mast while the probe was moving upwards is considered most likely to be an artifact associated with the field probe.

May 1, 2000 - After evaluating the measurement data obtained during the earlier session on April 6, it was decided that a supplemental set of measurements should be obtained to help confirm tentative conclusions. Measurement data from the May 1, 2000, session are presented in Figures 18-31. During this session, several different scenarios were used to better understand the RF fields within the working area and what was responsible for those fields. Based on the earlier set of data, the elevated fields within the lower half of the channel 41 aperture were hypothesized to be the result of direct upward radiation from the FM master antenna as well as reradiation and scattering of the FM fields from the auxiliary antennas for channels 4 and 5. The first scenario presented is that with all stations operating normally, including all FM stations. The second scenario presented is when all FM stations ceased operation from the master antenna. Other scenarios included removing one and, then, two FM stations from operating from the master antenna to observe for any measurable differences.

Examination of Figures 18-31 reveals that operation of the FM stations has a very significant effect on the presence of elevated fields within the lower half of the channel 41 aperture as had been hypothesized. Interestingly, however, operation with fewer FM stations from the master antenna did not appear to substantially reduce the maximum field magnitude within the working area but, instead, tended to change the number of points within that region exhibiting peak fields greater than the MPE limit.

For each of the scenarios examined, the following chart summarizes the findings relative to maximum field levels, expressed in terms of power density, within the working area beginning at the bottom of the channel 41 aperture.

Summary of RF field measurement data obtained May 1, 2000 in WTC antenna mast work area.		
Operating conditions	Probe movement	Maximum power density (mW/cm^2)
All FMs on	Up	1.63
	Down	1.81
All FMs off	Up	0.51 (single spike)
	Down	0.92 (single spike)
All FMs on but WKTU operating from uptown	Up	1.78
	Down	1.39
All FMs on but WKTU operating from uptown and WNYC off & channel 31 off	Up	1.65
[redacted]	Down	1.04

These data convincingly show that when the FM stations ceased operation from the master antenna, the field profile within the working area became very substantially weaker. Typical power densities were less than 0.1 mW/cm^2 throughout most of the

working area with the FM stations off. During the measurements, it was noted, as shown in Figure 22, that near the top of the channel 47 aperture, a narrow spike in the power density profile was observed. It is not apparent why this was observed but, in any event, the magnitude of the spike was less than 1 mW/cm^2, the MPE limit in the FM broadcast band. The most likely source of this narrow peak in field would be the channel 31 antenna that operates at 2,820 kW of ERP at 572 MHz where the MPE limit is 1.9 mW/cm^2. Thus, this value, while not clear what the source was, is less than the MPE for either the FM band or the UHF spectrum.

The data in the above chart also support that contention that RF fields within the working area, while observed to exceed the FCC limit for occupational/controlled exposures, do not substantially do so, typically being less than twice the MPE limit and, in addition, are not uniform in value along the mast. This finding is helpful in that it suggests that a wider range of options for controlling exposure of workers may be available. For example, the use of RF protective clothing would be feasible in these fields.

In all of these measurements, the Holaday Industies Model HI-6005 fiber optic isolated electric field probe proved to be invaluable for characterizing the RF field environment of the WTC antenna mast by allowing real-time observation of the local field strengths from the convenience of roof level. This made the entire measurement process highly efficient as local field conditions aloft could be ascertained immediately, thereby eliminating wasted time in downloading data from a meter that had to be transported to roof level each on each run and only then learning that a particular measurement may need to be repeated.

Discussion of Results and Implications for RF Safety

The RF field measurements reported here lead to a number of observations and insights pertinent to RF safety during the upcoming DTV antenna project work. These observations and insights are summarized as follows:

1. The RF field environment determined from the first set of measurements, within the proposed work area, is qualitatively similar for all four sides of the antenna mast without substantial differences between the four sides.

2. The magnitude of RF fields found during both measurement session are generally consistent and the results found during the second session on the south side of the mast should be applicable to the other three sides.

3. RF fields near the FM master antenna are very intense and may reach levels some 75 times the maximum permissible exposure (MPE) limit. Workers should not occupy the area below the bottom of the channel 41 aperture without very special precautions.

4. The field strengths within the FM master antenna aperture are sufficiently intense to preclude the use of time averaging as a method for mitigating exposure. This conclusion is based on the finding of plane wave equivalent power densities as great as 75 mW/cm^2 (at the lateral distance used in these measurements) and finding that. based on six-minute time averaging of whole-body exposures. this would imply a maximum exposure time of only 4.8 seconds during any six minute period. Ensuring that personnel would not be subject to these intense fields for longer than 4.8 seconds would is not practical and is subject to error.

5. RF fields at greater distances from the FM master antenna elements could prove to be more manageable such that compliance with the time-averaging aspects of the MPE limits would be practical. However, this would have to be evaluated with additional. on-site field measurements for the actual points where personnel might be located aloft near the FM master antenna.

6. RF fields within the channel 41/47 apertures. with channel 47 not operating from its main antenna, are very significantly less intense than near the FM master antenna and are readily amenable to mitigation. Maximum expected RF field levels within the channel 41/47 apertures should not exceed approximately 3 mW/cm^2.

7. In every instance, the strongest measured fields within the channel 41 aperture were within the bottom half. closest to the TV auxiliary antennas for channels 4 and 5 and the master FM antenna. These stronger field values are not representative of fields throughout the aperture but represent usually only a few points within the lower half of the aperture.

8. These higher peak fields in the lower half of the channel 41 aperture are due to two possible reasons: (a) direct radiation by the FM master antenna, and (b) reradiation of FM energy and scattering by the TV auxiliary antennas for channels 4 and 5. This conclusion is strongly supported by the observation that during measurements with none of the FM stations operating from the master FM antenna. only very weak fields were found. typically no more than 0.1 mW/cm^2.

9. Reduction of the magnitude of RF fields in the lower half of the channel 41 aperture would at first appear to be controllable by reducing the overall power transmitted from the FM master antenna and that this could be effected by turning off one or some of the FM stations. However. data collected during the second measurement session suggest that. at best. reduction of the number of FM stations operating from the master antenna only reduces the extent of the region within which the peak RF fields exceed the MPE limit. not the peak field magnitudes. This is apparently the result of the different frequencies associated with different stations producing slightly different field patterns by the master antenna. Based on this finding, it has to be concluded that actual power levels of each station operating from the master antenna would need to be reduced to accomplish the desired field strength reduction near the bottom of the work area. A power reduction to approximately 30% of normal operating power would likely result in fields not exceeding the MPE limit at any point

within the working area, however, this alternative approach was not evaluated during these measurements.

10. All of the field measurements reported here were conducted with channel 47 off the air. During the actual DTV antenna project work, channel 47 would operate at substantially lower power from a proposed temporary antenna located away from the main antenna mast. A reevaluation of the calculated results obtained in an earlier study of the RF fields that would be produced by operation of the channel 47 temporary antenna, within the working area parallel to the mast, indicated a maximum field of no more than about 0.017 mW/cm^2 on the mast[5].

11. The maximum field level on the mast from the channel 47 temporary antenna was projected to be about 2.6 mW/cm^2 at a height of 36 feet above the base of the mast and would exceed the MPE limit only within a region of about 2.5 vertical feet along the mast at that point.

12. During the DTV antenna project work, when men are aloft, channel 47 must never operate from its main antenna on the mast and all auxiliary antennas must be locked to prevent their activation.

13. At anytime workers must access the very top of the channel 47 aperture and bottom of the channel 31/2 aperture, channel 31 should cease operation and channel 2 should operate from its auxiliary location at the Empire State Building.

14. High intensity RF fields in front of the FM master antenna could produce significant interaction with steel being raised or lowered through the master antenna aperture during the DTV work and could lead to significant voltages between various metal components and possible arcing. This could also influence matching between the FM transmitters and the antenna, causing high VSWR at times. Consideration should be given to an evaluation of the VSWR on the master antenna while raising steel to assess the magnitude of possible reflected fields back to the master antenna. Caution should be exercised to avoid any transport of flammable liquids through the FM master antenna aperture while FM stations operate normally.

15. Mitigation of worker RF exposures within the lower portion of the channel 41 aperture could be achieved via the use of RF protective clothing, reduction of FM station operating power levels or ceasing operation of the FM stations all together during the mast work. Since WKTU has the option of now operating from an alternative uptown transmitter location, this would leave only two other higher power FM stations and one low power station at the WTC site. If the two higher power stations could operate at about 30% of their normal power level, the working area on

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[5] A Reevaluation of Radiofrequency Fields on the World Trade Center North Tower: A Supplemental Report prepared by Richard Tell Associates, Inc. for Motorola Land Mobile Products Sector, September 5, 1999, Revised March 21, 2000.

the mast should comply at all locations with the MPE limit. This was not, however, confirmed during these measurements.

16. Because of the potential for personnel to be exposed to strong RF fields when working on the WTC antenna mast, unless special precautions are taken, as described within this report, it is suggested that the work region be cleared prior to each work session by having an individual transit the region with a personal monitor set to alarm at 0.5 mW/cm^2 or 50% of the MPE limit to ensure that no areas exhibit fields above the alarm threshold. In the event that the monitor alarms, the person should immediately remove themselves from the region causing the alarm and an investigation made as to the cause so that it may be corrected before the work for the night is begun. Once the region has been cleared, this fact should be documented and retained.

17. At all times, personnel that are aloft at the site should be equipped with personal monitors set to alarm at 0.5 mW/cm^2 or 50% of the MPE limit. At any time that a worker's monitor alarms, they should immediately remove themselves from the area and the cause of the elevated RF field be determined and further investigated to ensure that exposure above the MPE will not occur.

18. All personnel involved in the DTV antenna project should participate in a RF safety awareness briefing prior to their work aloft at the WTC.

19. The latest version of the colorized RF field map for the roof of the WTC north tower should be consulted to identify those areas that should be avoided for long term exposure. This map has been reproduced as Appendix C.

20. An RF safety log book should be maintained throughout the duration of the DTV antenna project and archived for future reference. This log book should contain dated entries for each work session at the WTC and should include for each session: (1) date; (2) names of all personnel working aloft at any time during the work session; (3) time of initial clearing of work area (as described in 16 above) and whether excessive RF fields were determined and what was done to correct the issue ; (4) name of person confirming that channel 47 has either ceased operation or has transferred operation to their temporary antenna and time transfer occurred; (5) name of person confirming that all auxiliary antennas have been locked out and time this was accomplished; (6) name of person confirming that channel 31 and channel 2 have ceased operation from WTC mast, if this is necessary, during the work session due to personnel having to access the top of the channel 47 aperture and time that operation was ceased and reestablished; (7) notation of any high-field incidents noted during the work session, when they occurred, who noted them and what was done to correct the issue(s); (8) time that last man aloft returns to roof at end of work session; name and phone number of person confirming that each broadcast station has returned to normal operating conditions and time this occurs. An example log book sheet is provided in Appendix D that could be used for this purpose.

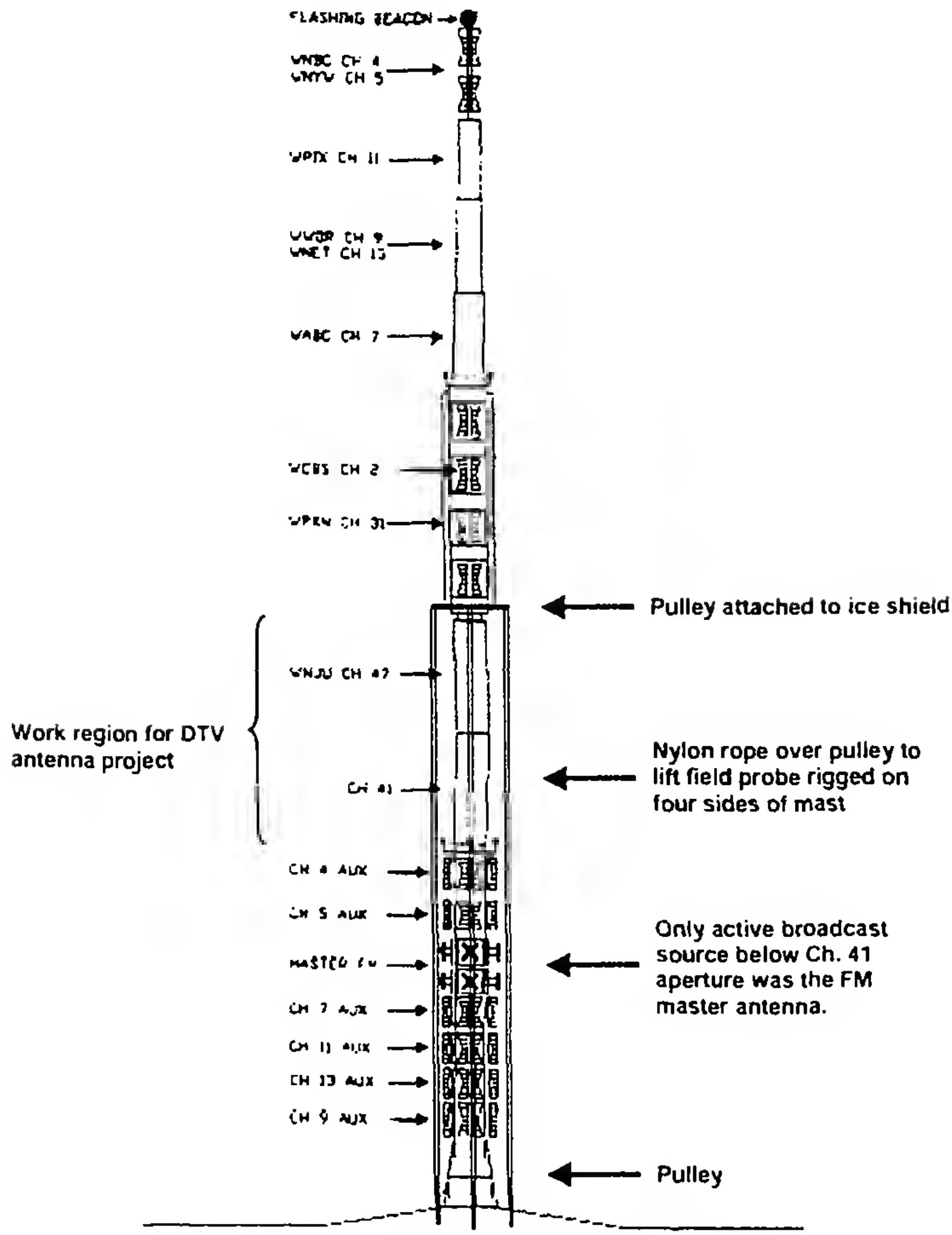


Figure 1. Simplified illustration of rigging arrangement of antenna mast. Adapted from drawing by D. W. Sargent Broadcast Services, Inc.

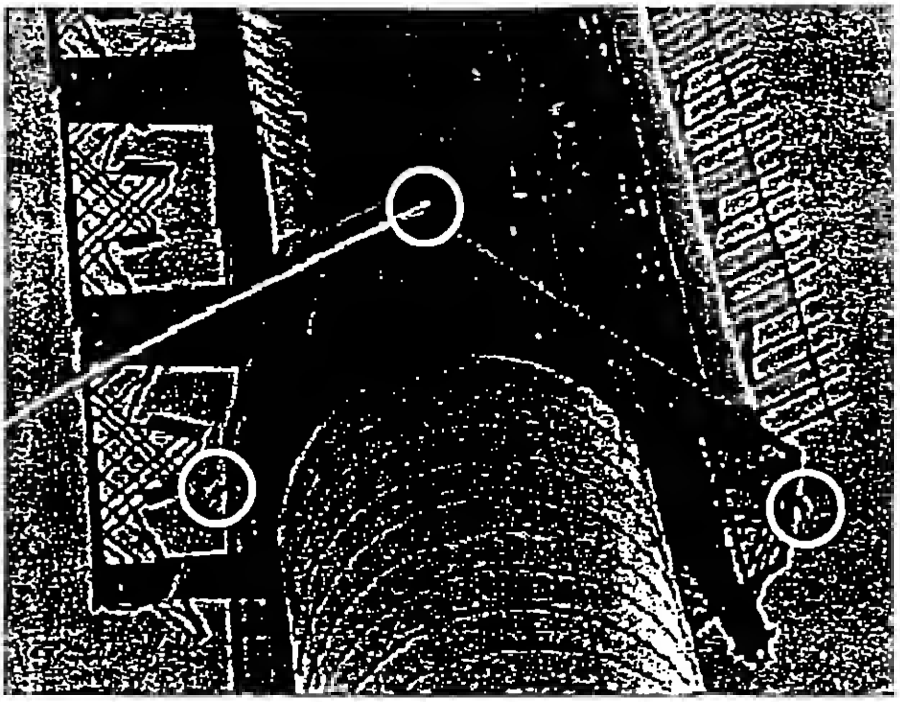


Figure 2. Close up photo showing attachment of nylon ropes at ice shield at top of the channel 47 antenna aperture. Pulleys allow the ropes to be pulled to elevate the electric field probe. A fourth pulley, on the opposite side of the mast, cannot be seen in this view.

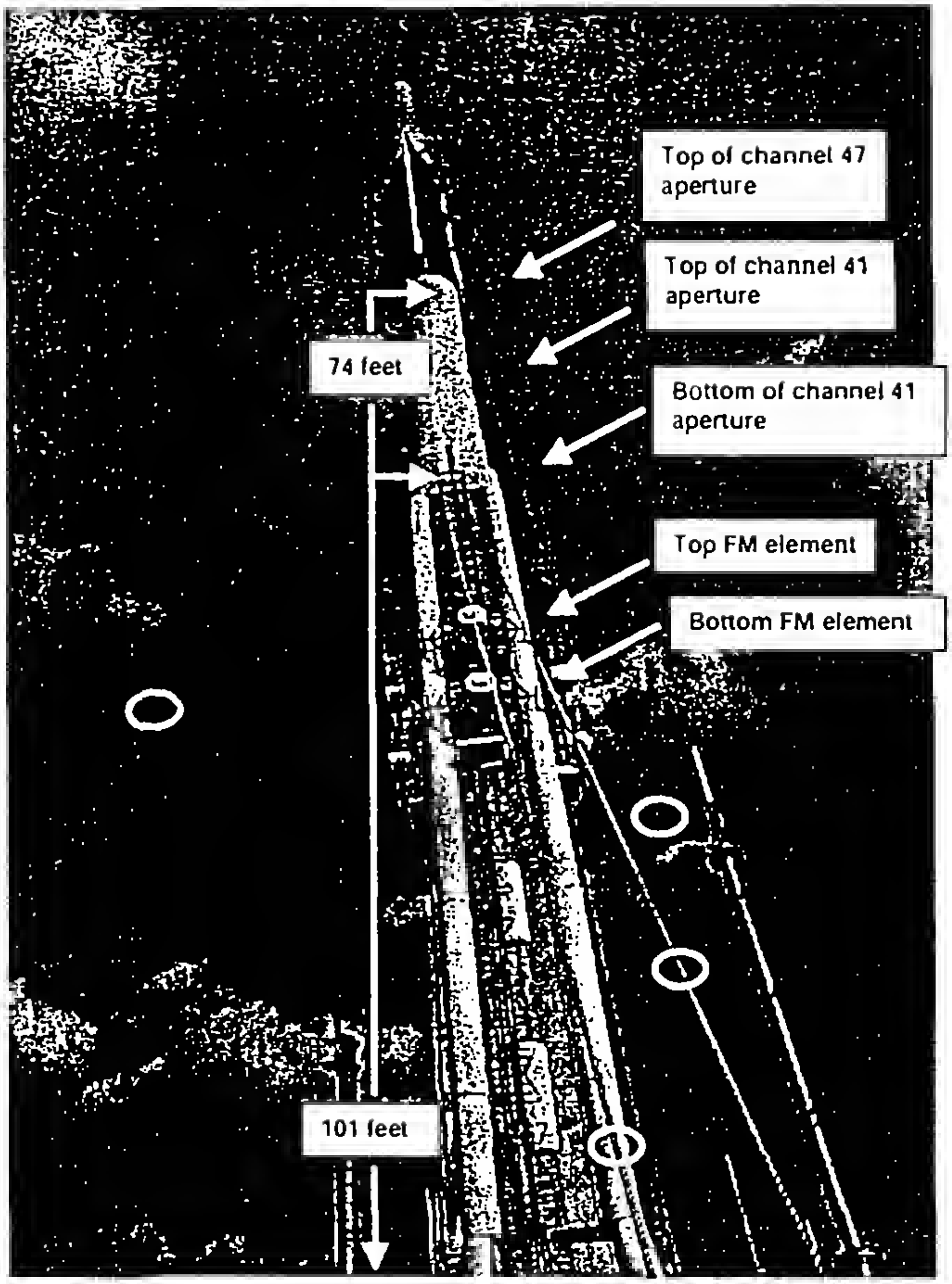


Figure 3. View of the antenna mast on the World Trade Center north tower showing ropes rigged to ice shield at top of the channel 47 antenna aperture. During measurements, the bottom ends of the ropes were brought from their temporary anchor points near the edge of the roof to the base of the mast and rigged over pulleys to facilitate up and down movement of the electric field strength probe. The principal working area that will be used during the antenna work is shown. The lower dimension is relative to the TV mast interface on the roof. Ropes are highlighted with ovals around them.

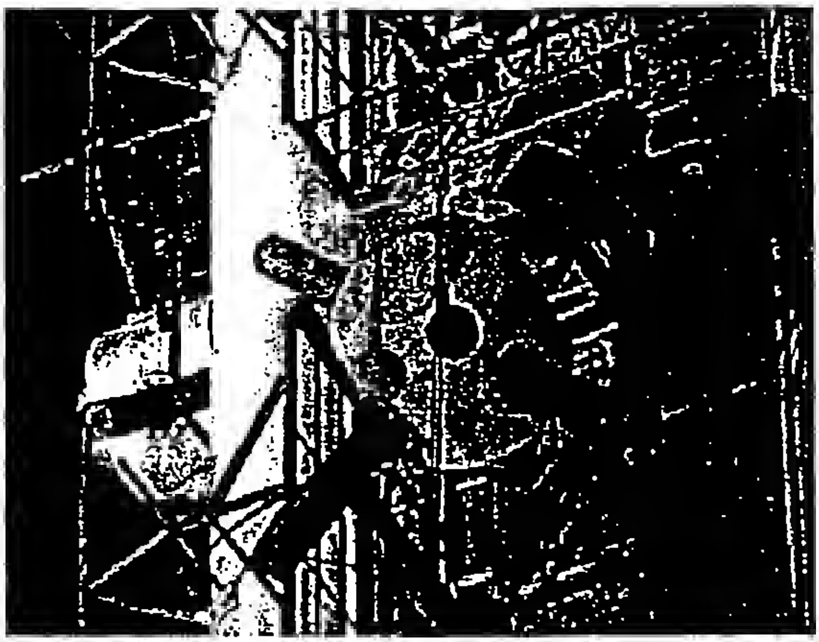


Figure 4. Telephoto shot of the Holaday Industries Model HI-6500 probe being elevated near one of the FM master antenna elements as it was raised to the ice shield above the channel 47 antenna aperture. High winds were problematic during the measurements on both occasions but particularly so during the second set performed on May 1, 2000. Despite keeping the ropes as taught as possible, there was probe movement during the raising process. Hence, especially when the probe passed near the FM master antenna elements and auxiliary antennas above the FM antenna, the probe would move in and out relative to the vertical rope axis leading to an observed effect of stronger and weaker fields just due to the effect of the wind.

Figure 5. The Holaday Industries Model HI-6005 isotropic field probe. The probe has two fiber optic cables emerging from the small cube containing electronics and self-contained battery. The three elements are arranged to provide for isotropic response to all electric field polarization components. Using a special, 100 meter long fiber optic cable, electric field strengths were able to be observed in real time as the probe was elevated to different locations parallel to the antenna mast permitting immediate indication of the RF field strength.

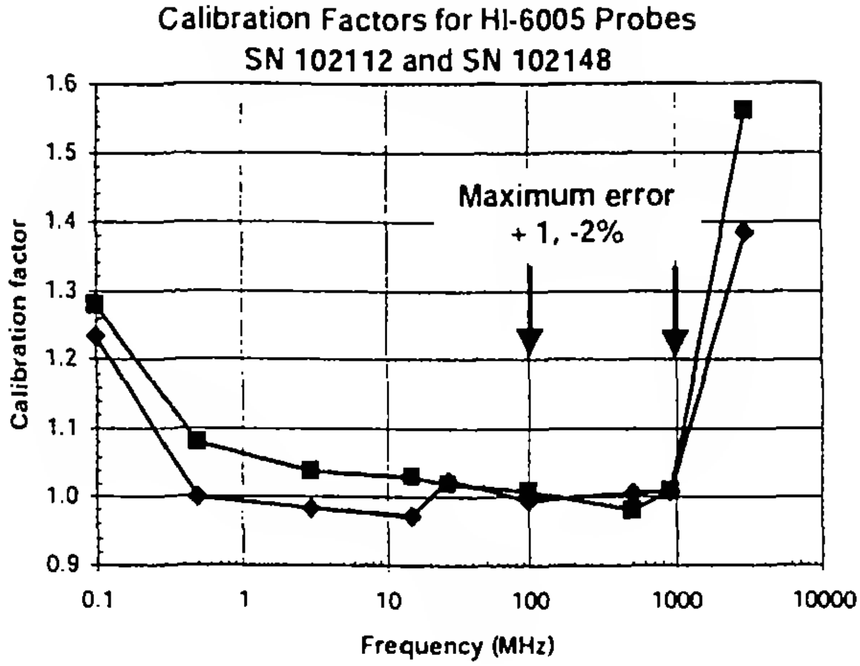


Figure 6. Calibration factors for the Holaday Industries Model HI-6005 isotropic field probe (SN 102112). In the frequency range applicable to the predominate RF fields near the antenna mast, the maximum error was measured to be no greater than ± 1%.

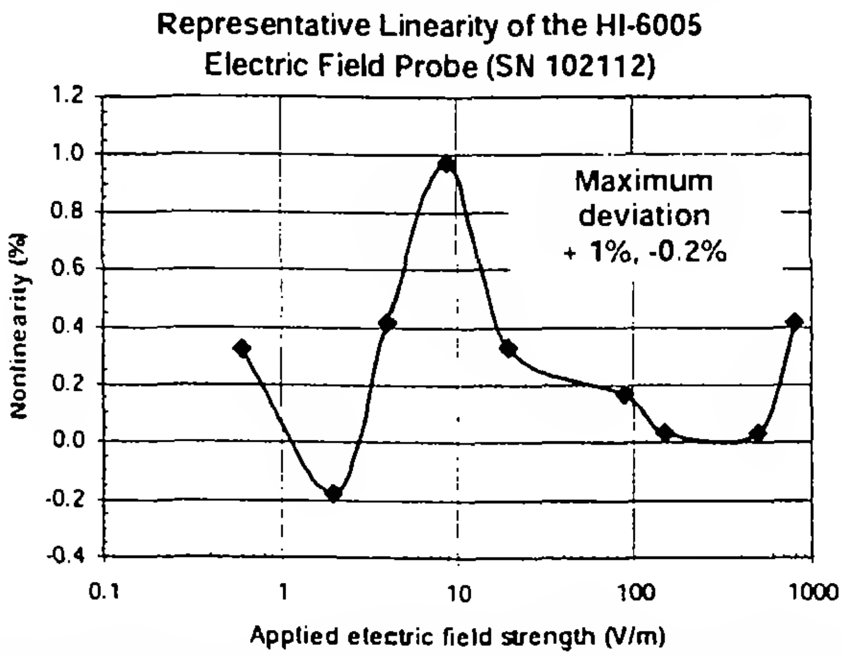


Figure 7. Measured linearity of the Holaday Industries Model HI-6005 isotropic field probe (SN 102112). The maximum deviation from perfect linearity over the electric field strength range of 0.5 V/m to 900 V/m was found to be + 1%, - 0.2%.

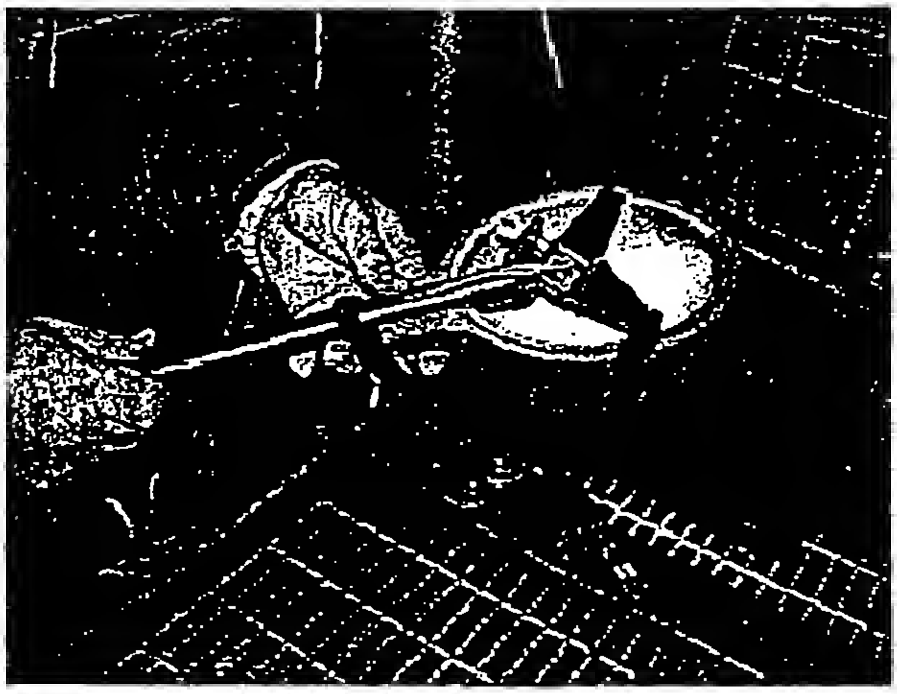


Figure 8. The isotropic field probe was placed inside a Styrofoam protective sphere during its use on the second set of measurements performed May 1, 2000. The two hemispherical Styrofoam shells were fastened with Velcro strips and the entire assembly was then taped to one of the ropes rigged to the mast. By slowing pulling on one rope, the field probe could be elevated to any height between the roof and the ice shield above the channel 47 antenna aperture.

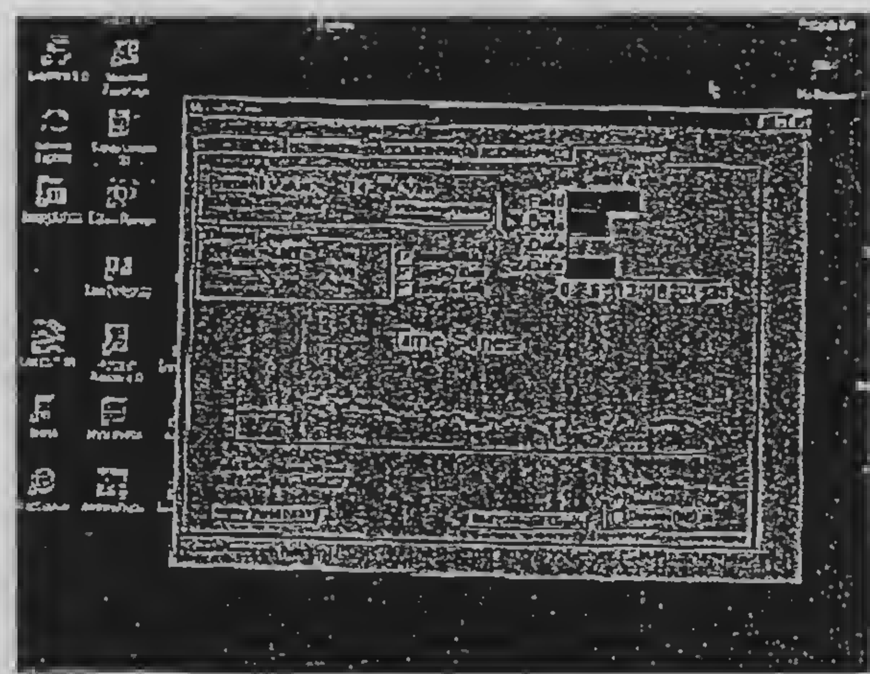


Figure 9. The Holaday Industries Model HI-6005 isotropic field probe was read by using the Holaday Industries ProbeView™ software package. This photo of a laptop computer screen, taken during the actual field measurements, illustrates the ability of the software to simultaneously display the individual x, y and z polarization components of the electric field strength as well as the resultant field magnitude. The data are saved to files allowing them to be analyzed in more detail at a later time.

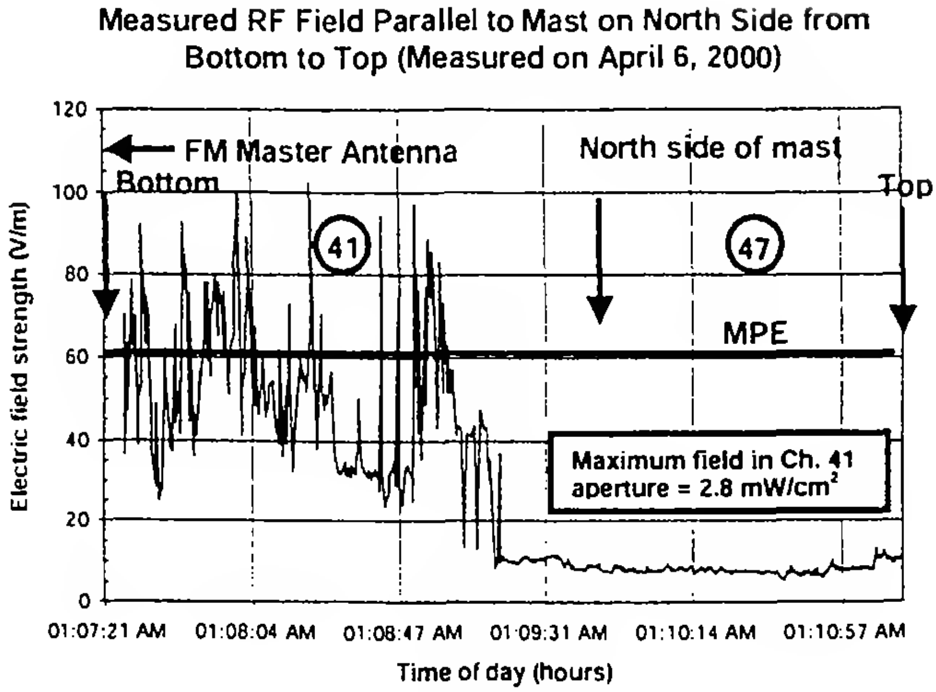


Figure 10. Electric field strength measured parallel to antenna mast on April 6, 2000, with normal broadcast operations, except with channel 47 off, with all FM stations on and probe moving up on north side of mast.

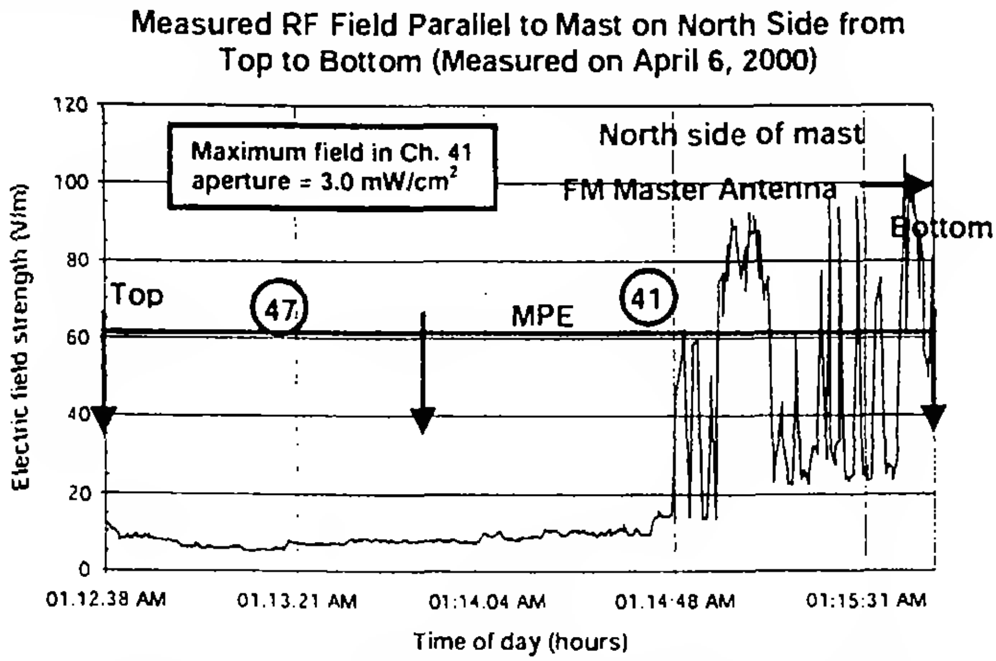


Figure 11. Electric field strength measured parallel to antenna mast on April 6, 2000, with normal broadcast operations, except with channel 47 off, with all FM stations on and probe moving down on north side of mast.

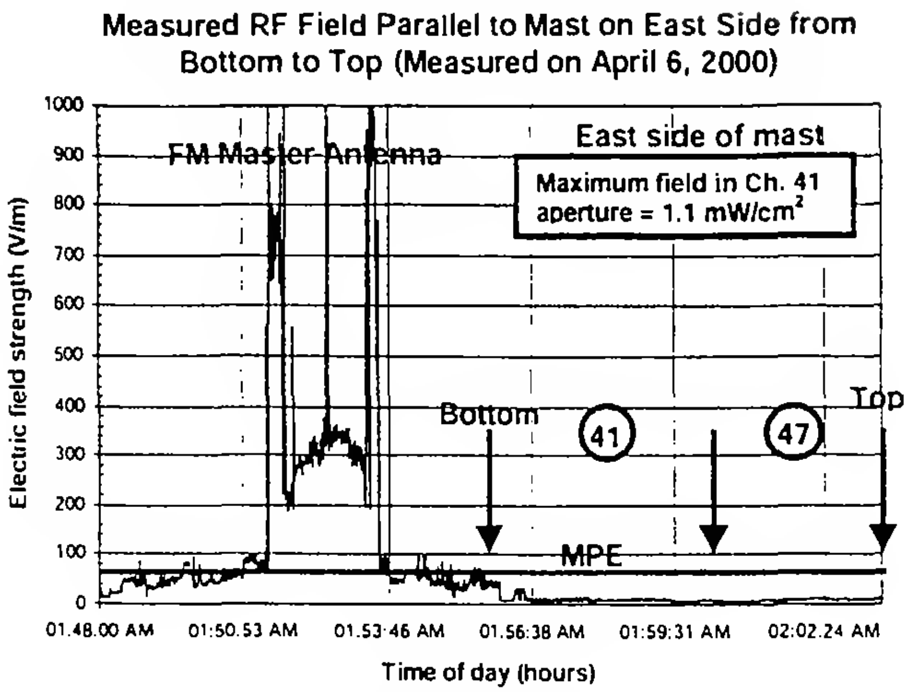


Figure 12. Electric field strength measured parallel to antenna mast on April 6, 2000, with normal broadcast operations, except with channel 47 off, with all FM stations on and probe moving up on east side of mast.

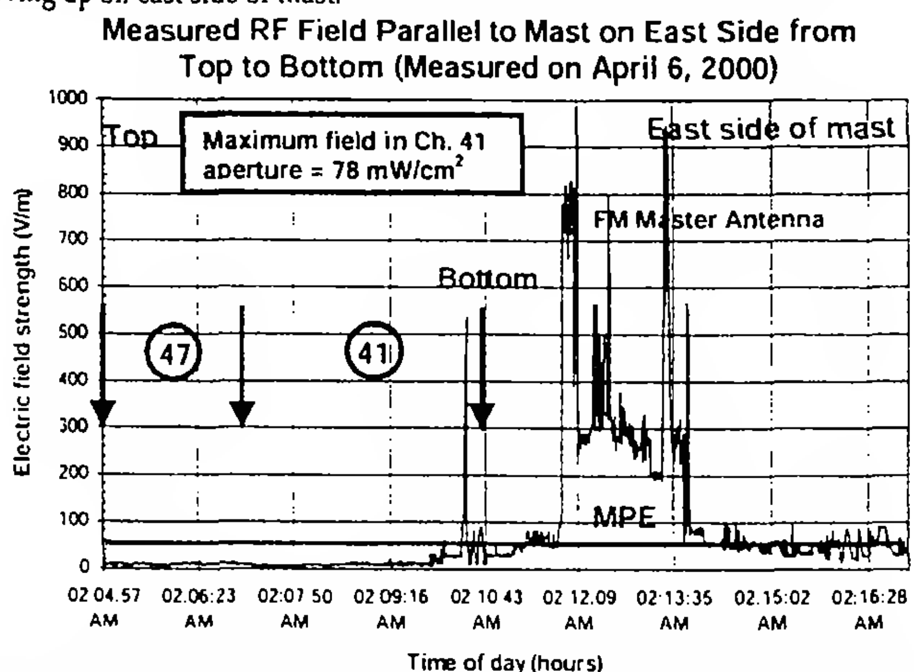


Figure 13. Electric field strength measured parallel to antenna mast on April 6, 2000, with normal broadcast operations, except with channel 47 off, with all FM stations on and probe moving down on east side of mast.

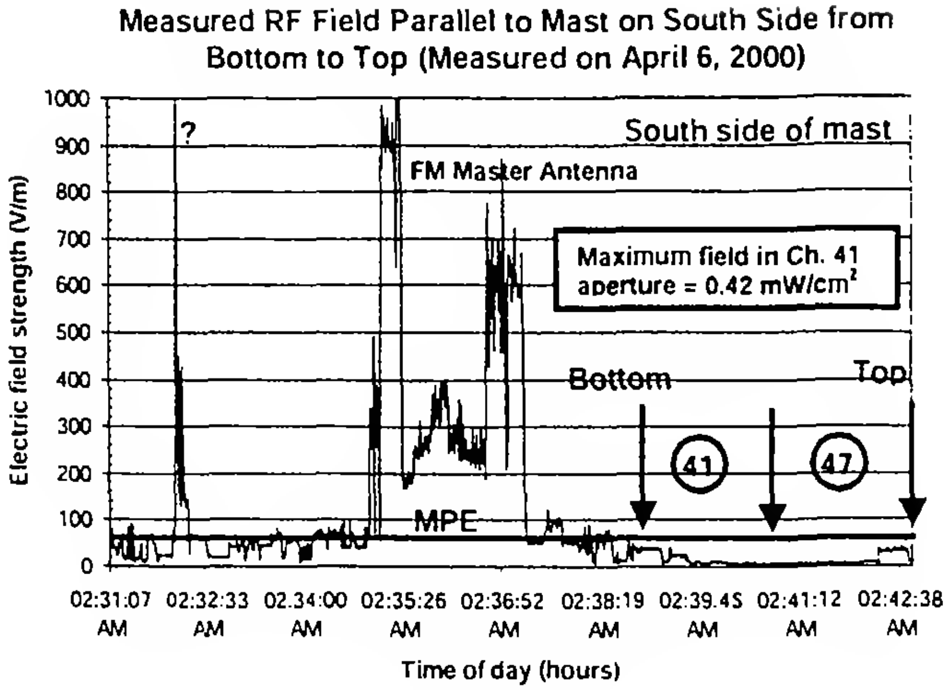


Figure 14. Electric field strength measured parallel to antenna mast on April 6, 2000, with normal broadcast operations, except for channel 47, with all FM stations on and probe moving up on south side of mast.

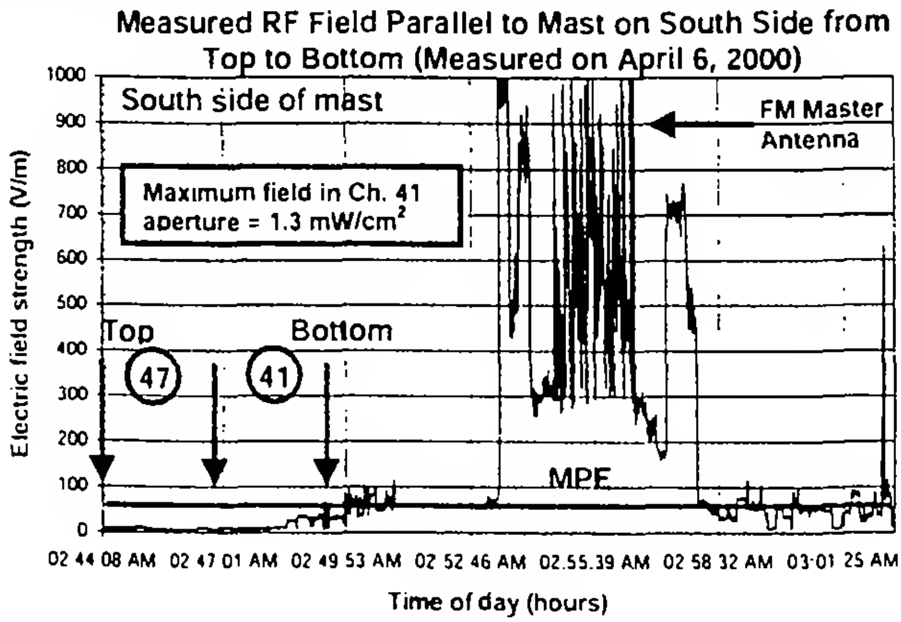


Figure 15. Electric field strength measured parallel to antenna mast on April 6, 2000, with normal broadcast operations, except for channel 47, with all FM stations on and probe moving down on south side of mast.

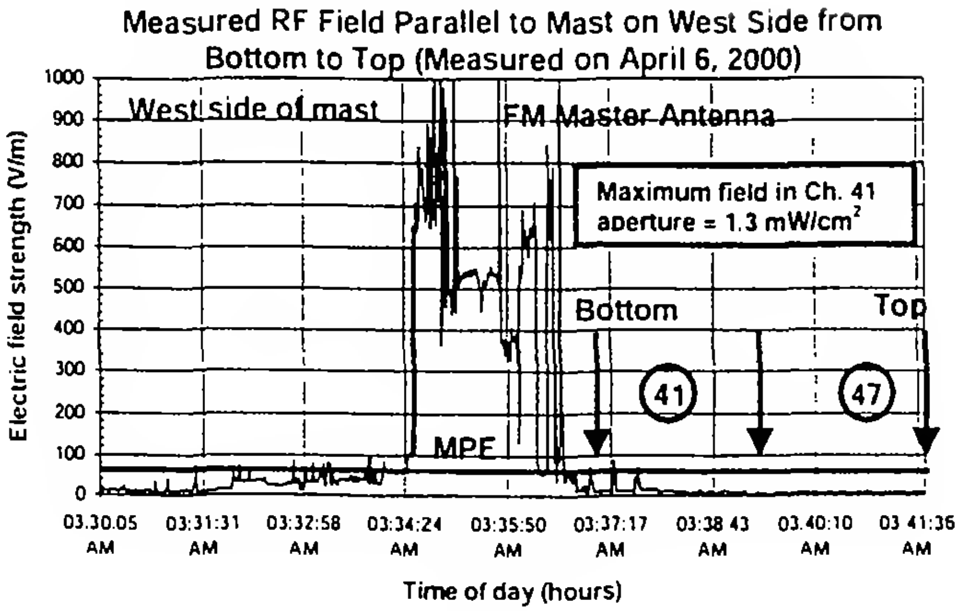


Figure 16. Electric field strength measured parallel to antenna mast on April 6, 2000, with normal broadcast operations, except for channel 47, with all FM stations on and probe moving up on west side of mast.

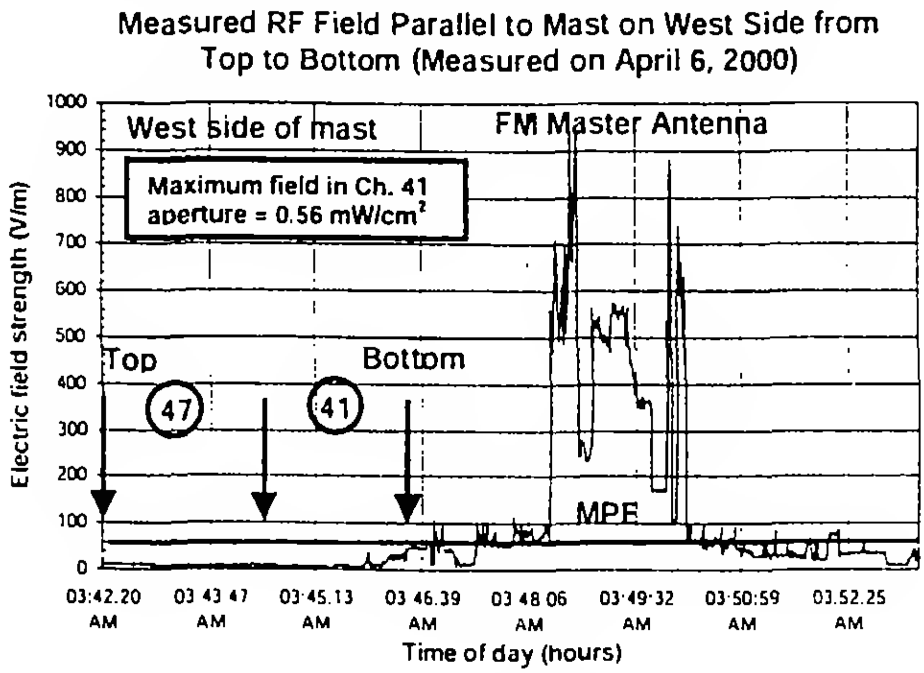


Figure 17. Electric field strength measured parallel to antenna mast on April 6, 2000, with normal broadcast operations, except for channel 47, with all FM stations on and probe moving down on south side of mast.

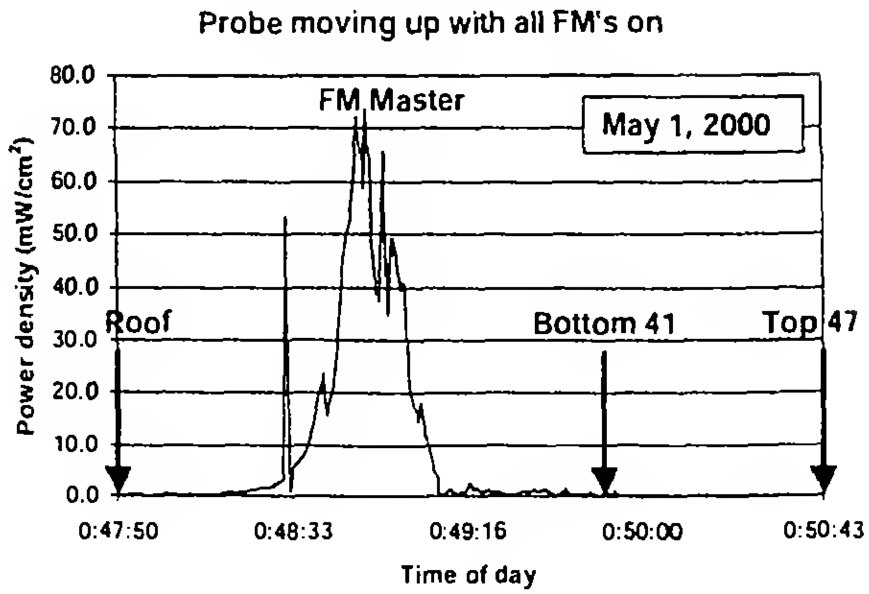


Figure 18. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations and all FM stations on and probe moving up.

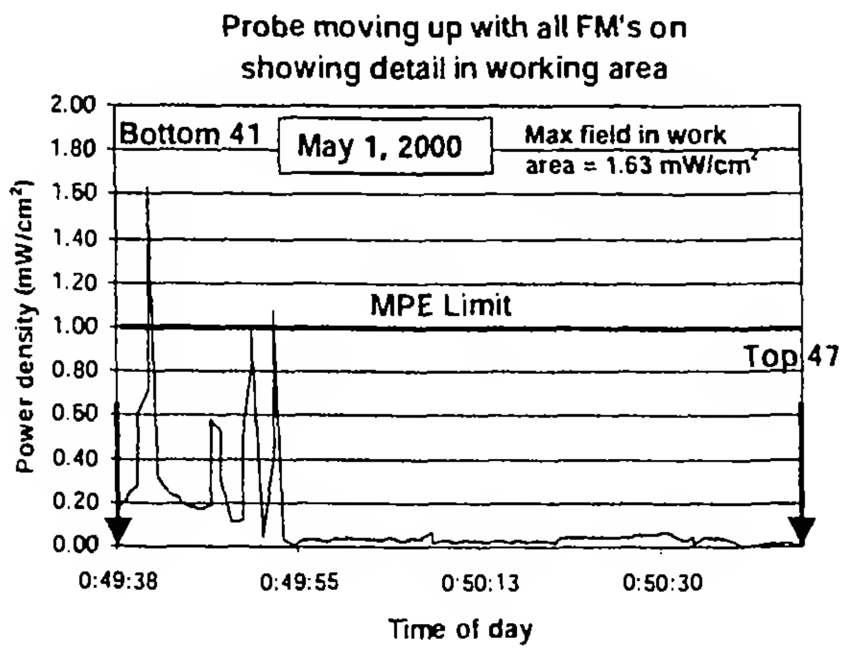


Figure 19. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations and all FM stations on and probe moving down.

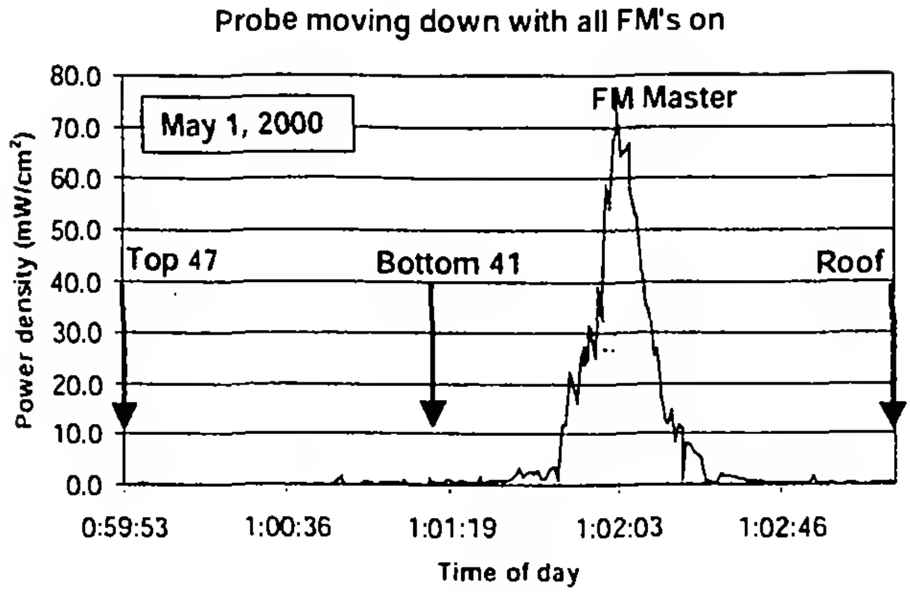


Figure 20. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations and all FM stations on and probe moving down.

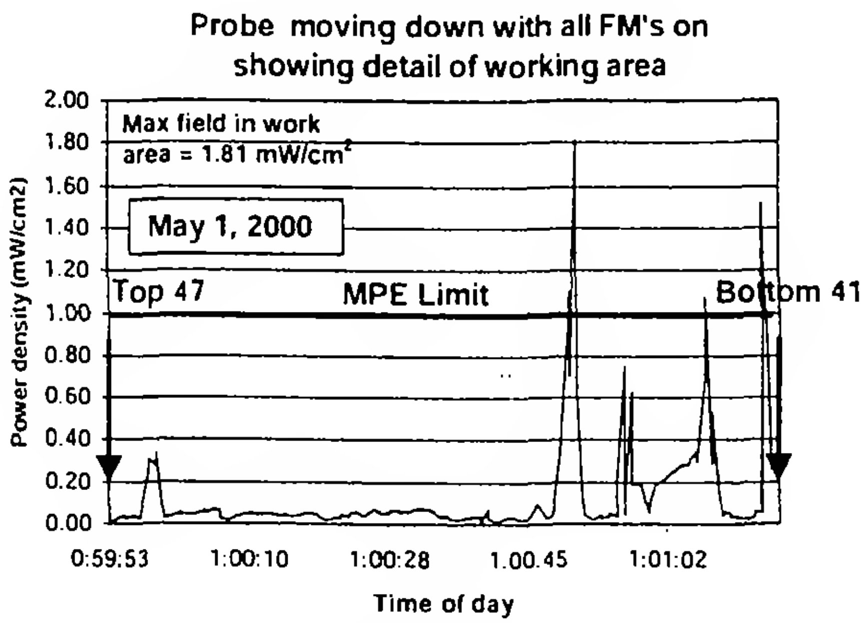


Figure 21. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations and all FM stations on and probe moving up.

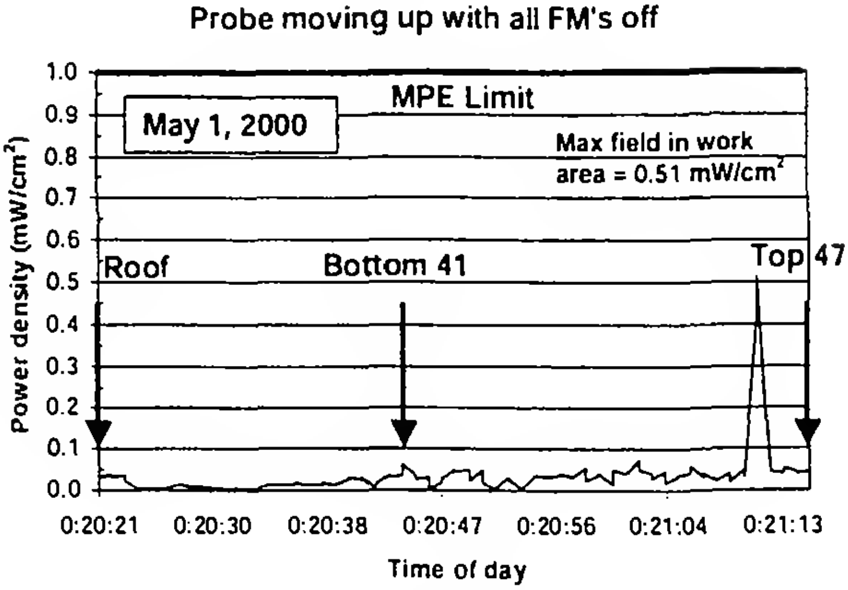


Figure 22. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations but with all FM stations off and probe moving up.

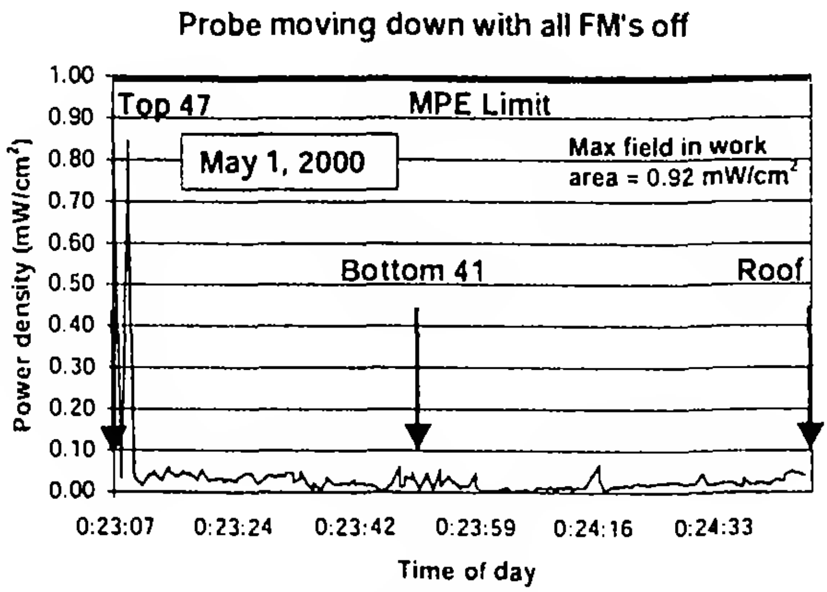


Figure 23. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations but with all FM stations off and probe moving down.

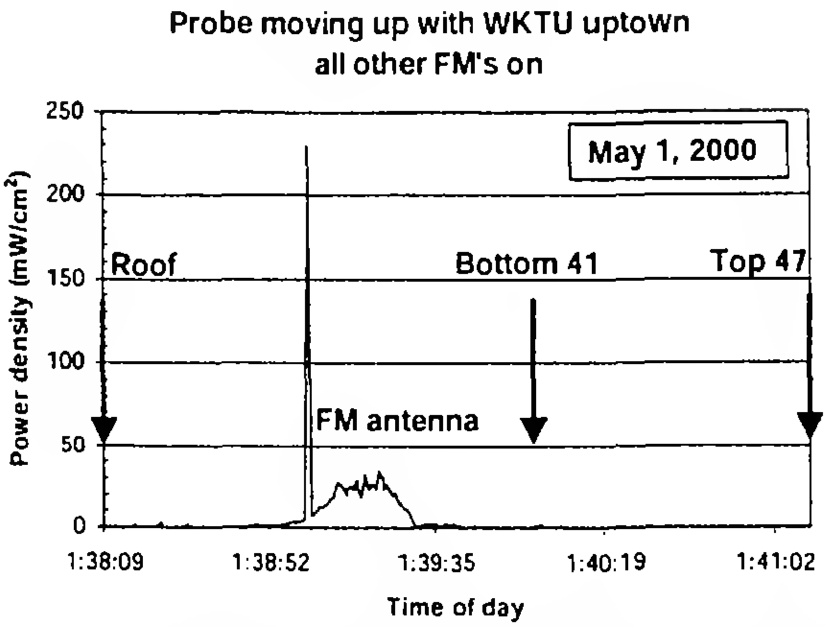


Figure 24. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations but with WKTU operating from uptown site and probe moving up.

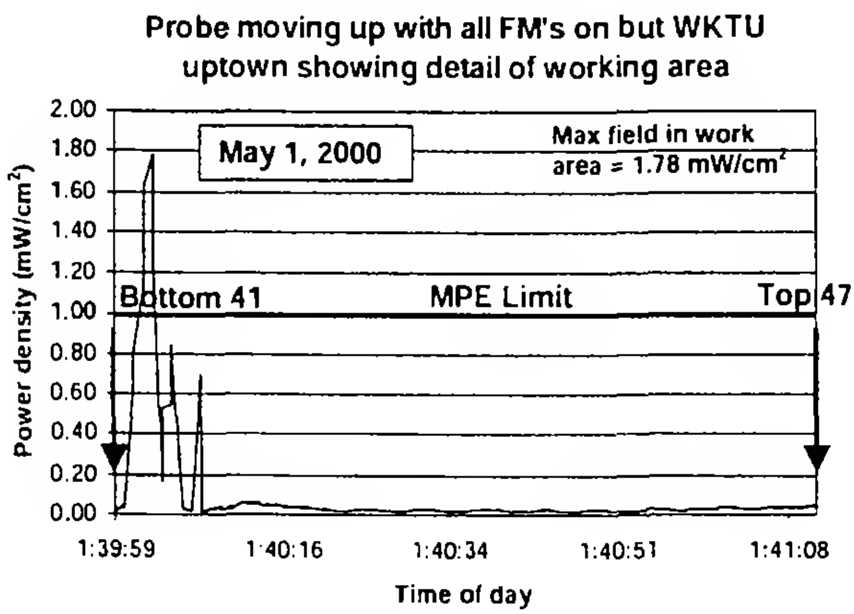


Figure 25. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations but with WKTU operating from uptown site and probe moving up showing detail of the working area.

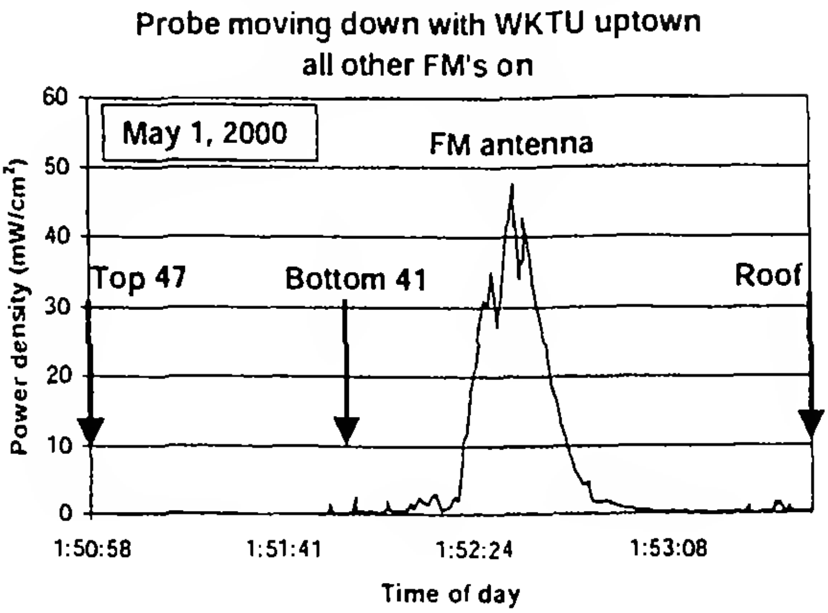


Figure 26. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations but with WKTU operating from uptown site and probe moving down.

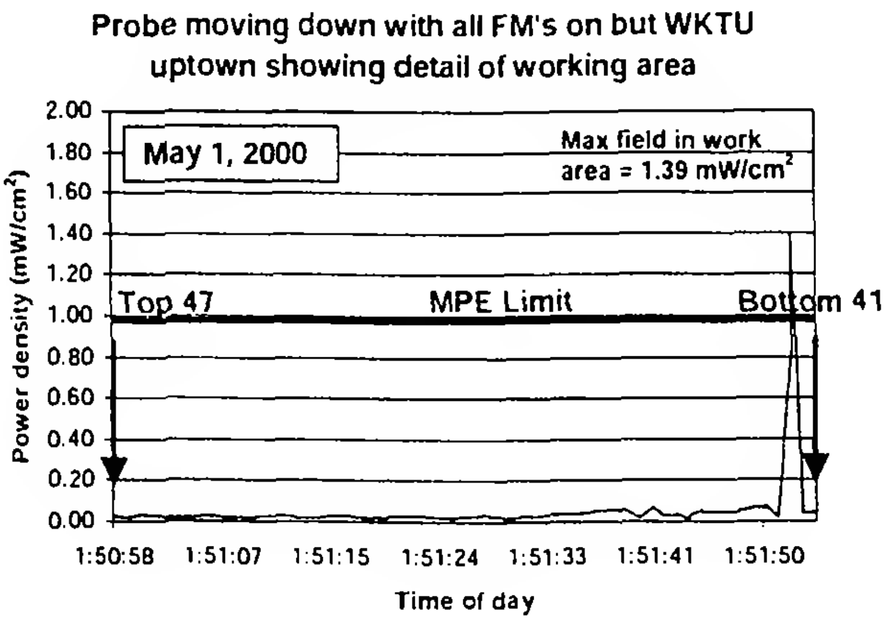


Figure 27. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations but with WKTU operating from uptown site and probe moving down showing detail of working area.

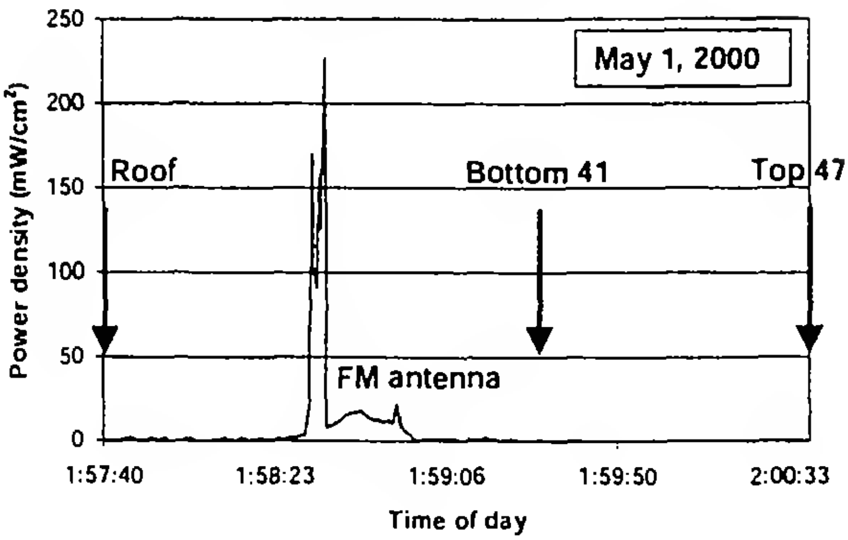


Figure 28. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations but with WKTU operating from uptown site, WNYC off and probe moving up.

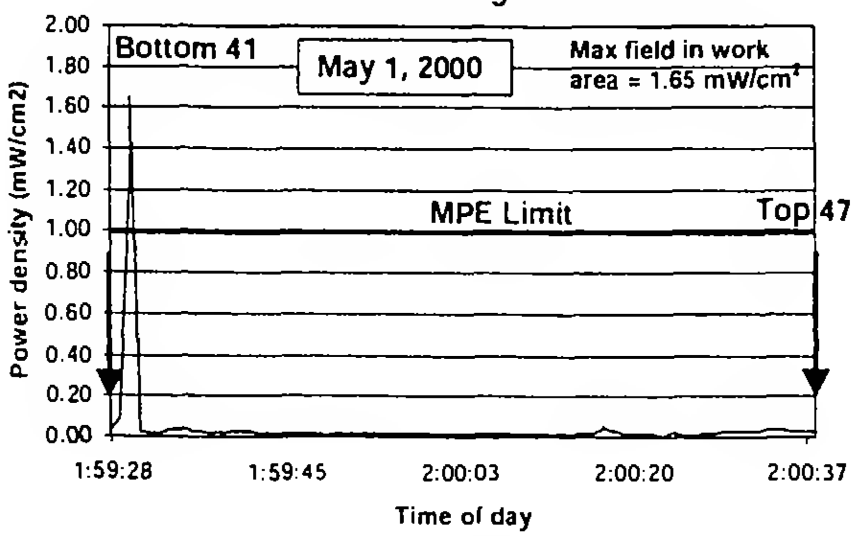


Figure 29. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations but with WKTU operating from uptown site, WNYC off and probe moving up showing detail of working area.

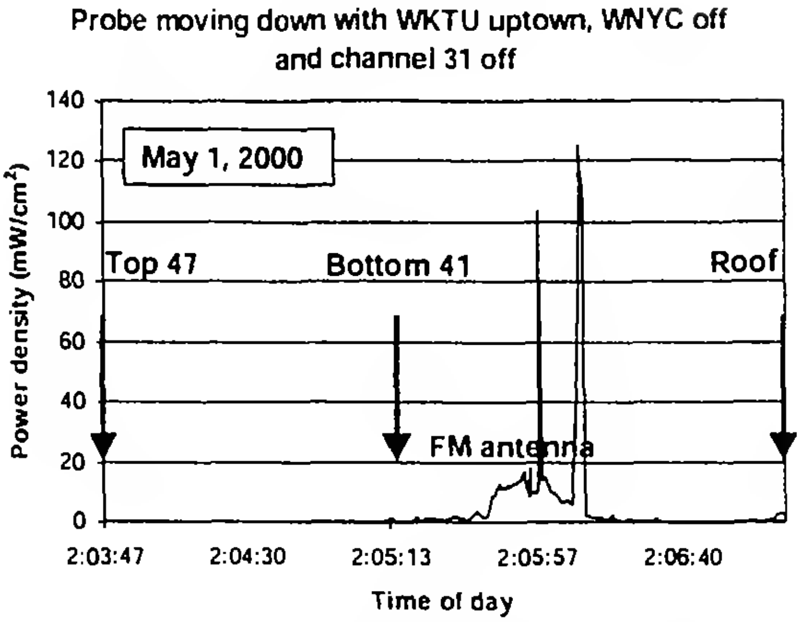


Figure 30. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations but with WKTU operating from uptown site, WNYC off and probe moving down.

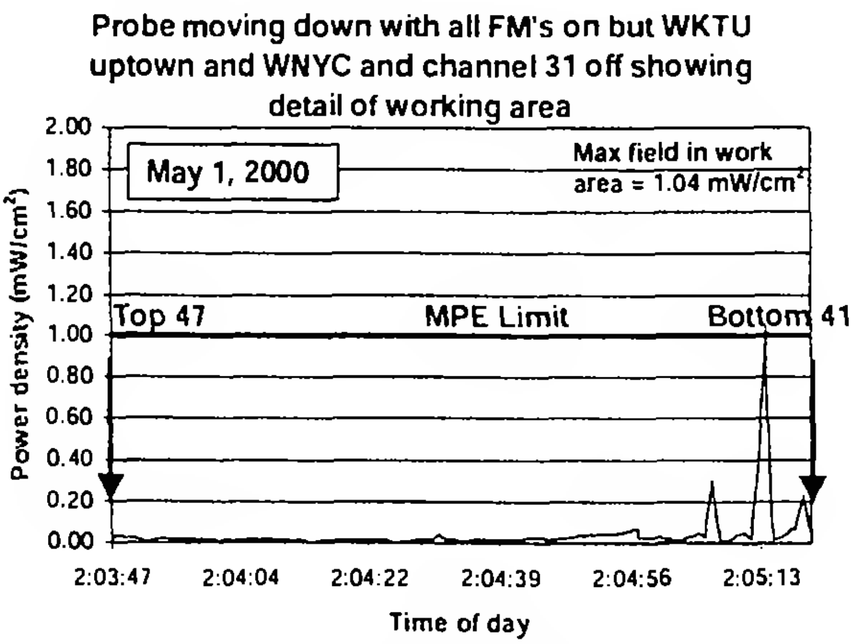


Figure 31. Plane wave equivalent power density measured parallel to antenna mast on May 1, 2000, with normal broadcast operations but with WKTU operating from uptown site, WNYC off and probe moving down showing detail of working area.

APPENDIX A - LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE) Adopted by the Federal Communications Commission (Reference = Table 1. Title 47 CFR)

(A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	$(900/f^2)$*	6
30-300	61.4	0.163	1.0	6
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	$(180/f^2)$*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz

*Plane-wave equivalent power density

NOTE 1: *Occupational/controlled* limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2: *General population/uncontrolled* exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

Appendix B: HI-6005 Electric Field Probe

New Technology Solving EMF Problems

The new **HI-6005** Electric Field Probe embodies the latest innovations in isotropic sensor design and low noise, miniaturized electronics.

The HI-6005 is a fully intelligent sensor enabling fast and accurate EMF measurements with industry-leading performance specifications. Optical coupling to a variety of readout options makes this new probe ideally suited for a wide range of field monitoring applications.

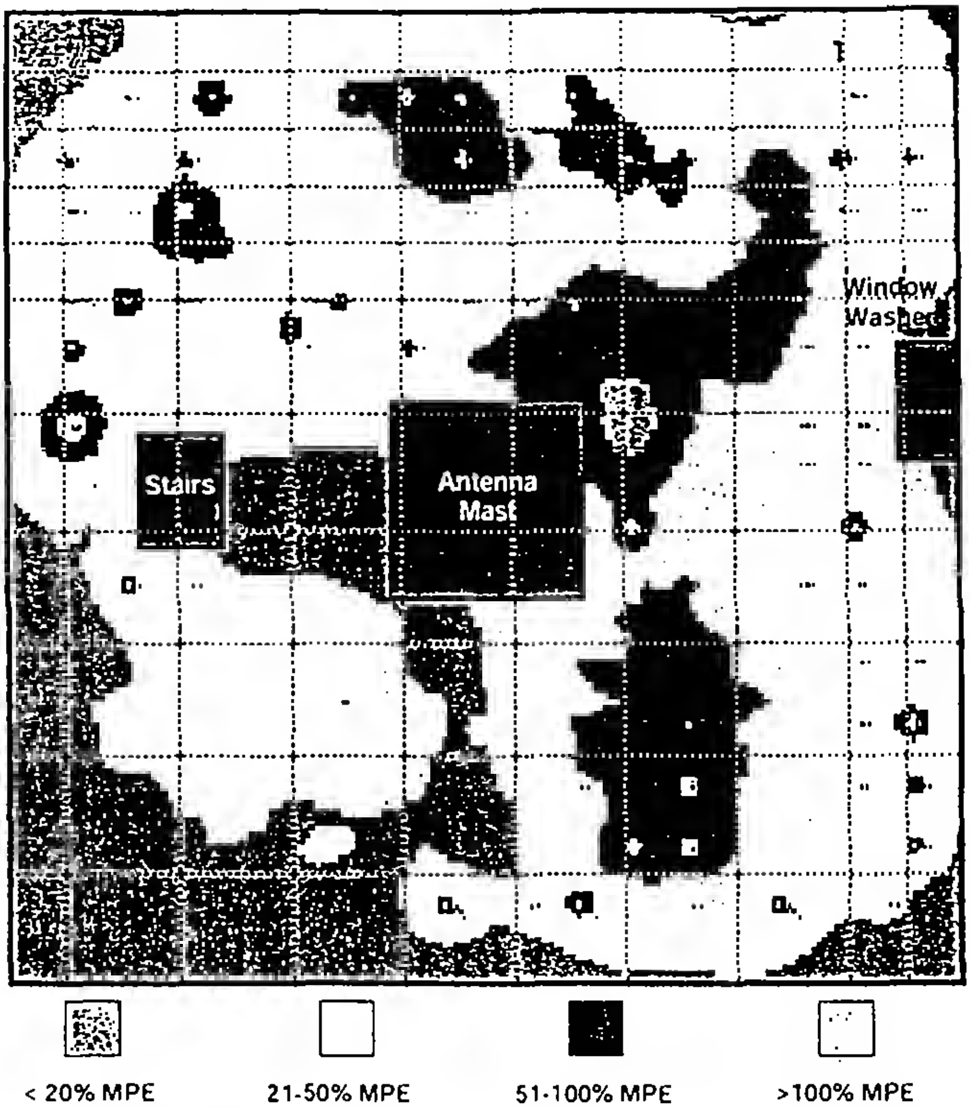
Specifications

Sensor Type	Electric Field
Detection	Isotropic (X, Y and Z Axis Readings)
Dynamic Range	0.5 – 800 V/m (>64 dB, Single Range)
Resolution	0.01 V/m
Readout Units	V/m, V^2/m^2, mW/cm^2
Frequency Response	100 kHz – 5 GHz
Accuracy	± 1 dB from 26 MHz – 2 GHz ± 0.5 dB at Calibration Frequencies
Isotropic Deviation	± 0.5 dB
Linearity	± 0.5 dB
Probe Response Time	5 µsec (typical)
Overload Withstand	>1500 V/m Continuous Field
Physical Interface	Duplex Optical Fiber (200 micron multimode) FSMA Connectors
Operating Range	10°C to 40°C 5% to 95% Relative Humidity, Non-Condensing
Operating Time	10 Hours Continuous Use
Battery	Rechargeable NiMH
Battery Charger	100-240 VAC Universal Input 2 Hour Charge Time from Fully-Depleted Battery
Dimensions	32mm x 32mm x 32mm Cubical Housing 43mm Sensor Protection Caps
Mounting	¼-20 UNC Internal Thread
Weight	80g

Holaday Industries, Inc.
14825 Martin Drive
Eden Prairie, Minnesota, 55344
Telephone: 952-934-4920
Facsimile: 952-934-3604
E-mail: sales@holadayinc.com
Internet: www.holadayinc.com

Holaday Industries, UK
Shieling House, Invincible Road
Farnborough, Hants, UK GU14 7QU
Tel/Fax: (44) 1252 540955
E-mail: sales-eu@holadayinc.com

Appendix C: Colorized WTC North Tower Roof Map of RF Fields



A 1999 reevaluation of RF fields from measured ambient fields of normal broadcasting operations with calculated contribution of all wireless telecommunications antennas (see footnote on page 10). Maximum field is 299.6% MPE.

1999 Statistical summary of RF Fields on WTC roof		
Percent occupational MPE range (%)	Roof area in this range (ft^2)	Percent of roof area in this range (%)
0-20	5490	20.18
21-50	17508	64.36
51-100	4012	14.75
>100	195	0.72

Appendix D: Example RF Safety Log Book For WTC DTV Antenna Project

Date: ______________________

Personnel working aloft:

1. ________________________ Personal monitor: Yes ___ No: ___
2. ________________________ Personal monitor: Yes ___ No: ___
3. ________________________ Personal monitor: Yes ___ No: ___
4. ________________________ Personal monitor: Yes ___ No: ___

Clearing of work area:

1. Who did it: __________________
2. Time completed: ________________
3. All points less than threshold? _______ Yes _______ No
4. Description: ____
5. If no, what was done to correct issue?

   ____

   ____

Confirmation that channel 47 is off or on temporary antenna:

1. Name of person: ___________________ Phone: _________________
2. Time this was done: ___________________

Confirmation that all auxiliary antennas are locked out:

1. Name of person: ___________________ Phone: _______________
2. Time this was done: ___________________

Confirmation that channel 31 and 2 not operating from mast, if needed:

1. Name of person: ___________________ Phone: _______________
2. Time this was done: ___________________
3. Time stations returned to normal operation from mast: ______________

High-field incident(s) observed during work session: Yes _____ No _____

1. When: _____________________
2. Who noted them: ________________________
3. What was done to correct issue(s):

   ____

   ____

Time last man aloft during work session back on roof: __________________

Stations returned to normal operations:

1. Person confirming return to normal operation on mast: ___________
2. Phone: ____________
3. Time stations back on mast: _________________

Notes: ____

____

____

APPENDIX A-10

Memorandum 7/28/2000, Regarding
Radiation Safety Survey One WTC

THE PORT AUTHORITY OF NY & NJ MEMORANDUM

TO: George Tabeek, Project Manager
FROM: Paul W. Mitchell
DATE: July 28, 2000
SUBJECT: **RADIATION SAFETY SURVEY - ONE WORLD TRADE CENTER**

COPY TO: N. Chanfrau, D. Karpiloff, M. Plaskon, P. Taylor, G. Wojnar

On June 14, 2000, George DeFreese of my staff conducted the semi-annual Radiation Safety Survey of the Barringer IONSCAN 400 Ion Mobility Spectrometer located in the lobby of 1 WTC. Possession and use of the instrument is in compliance with the conditions of the general license. The conditions of the general license are found in Appendix A at the rear of the instrument's instruction manual. The instrument is registered with the New York State Department of Labor registration number X-14101.

The survey included an inspection of the storage area and of the instrument, and leak test sampling. The results of the survey are attached. Leak test sampling of the instrument was performed in order to detect removable (leaking) radioactive material from the Nickel 63 sealed source unit. The sample was submitted to Monitoring Services for analysis and the result was found to be acceptable. A copy of the report is attached for your records. A copy of the current leak testing result (not older than six months) must accompany the instrument at all times.

The next radiation safety survey will be conducted in November, 2000.

If you have any questions about this survey or require information regarding radiation safety, please call me at (201) 216-2173.

Paul W. Mitchell

Paul W. Mitchell, CIH
Manager
Occupational Health
Inspection and Safety Division

Attachments

Post-it™ brand fax transmittal memo 7671 | # of pages ▸

To UNDER	From
Co. OSH 1999	Co.
Dept.	Phone #
Fax # RADIAT 102	Fax #

WORLD TRADE DEPARTMENT
WORLD TRADE CENTER
RADIOACTIVE SAFETY SURVEY

INSTRUMENT	REMOVABLE RADIOACTIVITY TEST RESULT	INSTRUMENT IS SECURELY STORED	INSTRUMENT IS PROPERLY LABELED	OPERATOR'S MANUAL IS AVAILABLE
Barringer Instruments IONSCAN 400 Ion Mobility Spectrometer Serial No. 10A	Acceptable	Yes	Yes	Yes

Monitoring Services

P O BOX 266677 · HOUSTON, TEXAS 77256-0848 · AREA CODE 713/242-9038 · FAX 713/242-9039

SEALED SOURCE LEAK TEST CERTIFICATE

PORT AUTHORITY OF NY & NJ
241 ERIE STREET ROOM 306
JERSY CITY ,NJ 07310
ATTN OF: PAUL MITCHELL

C FILE 2194

S FILE 22436

N FILE 1662

INVOICE NO. ____ DATE ____

RADIONUCLIDE NI-63

ACTIVITY 15 MCI CI SERIAL NO 10A

WIPE DATE 061400 WIPED BY ____

EFF .652

GROSS CPM 31 BKG CPM 21 NET CPM 10

$$\frac{\text{NET CPM}}{\text{EFFX2 } 22\text{X}10^6 \text{ DPM}/\mu \text{ CI}} = \text{MICROCURIE}$$

THE ABOVE SOURCE WIPE TEST HAS BEEN ASSAYED IN ACCORDANCE WITH OUR RADIOACTIVE MATERIAL LICENSE AND THE APPROPRIATE REGULATORY REQUIREMENTS. THE REGULATIONS DEFINE A LEAKING SOURCE AS ONE FROM WHICH AN APPROPRIATE WIPE TEST HAS REMOVED 0.005 MICROCURIE OR MORE OF ACTIVITY

THE REMOVABLE ACTIVITY WAS 6.91E-06 MICROCURIE

ASSAY NO. 070500 11 DATE 07-05-20.00

ASSAYED BY [signature]

APPENDIX B

Photo #1:
360-Foot antenna
mast on One World
Trade Center.

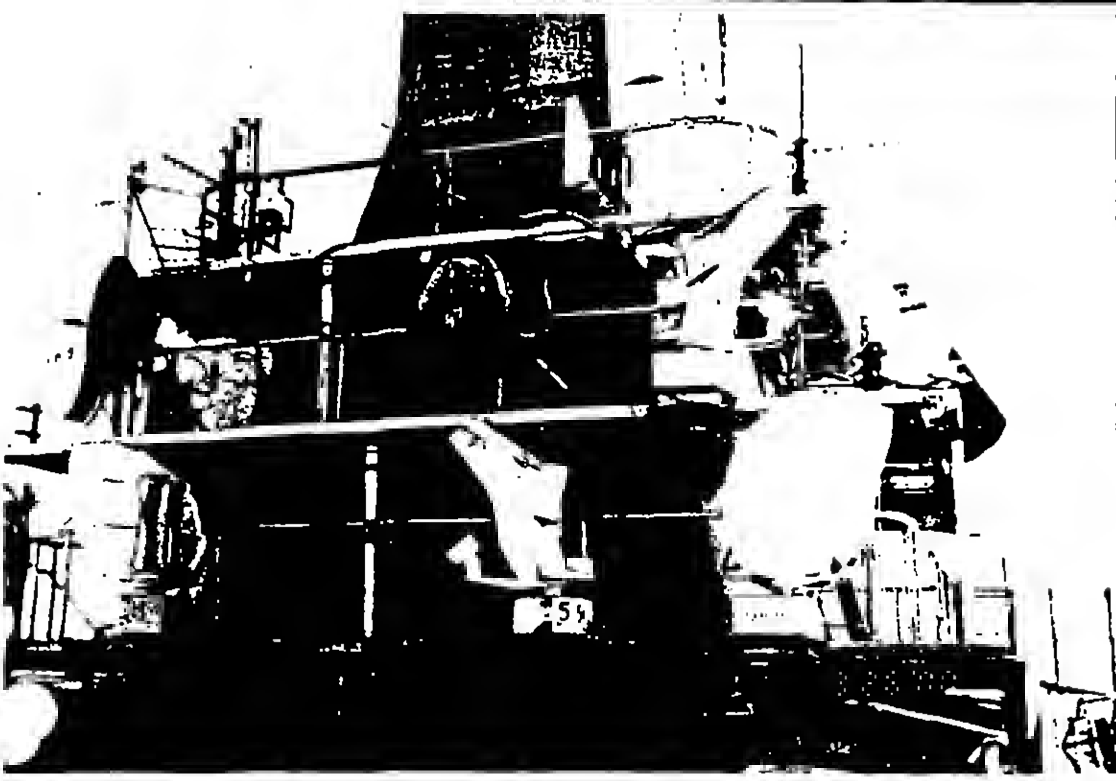


Photo #2: Base
of antenna mast
on One World
Trade Center.

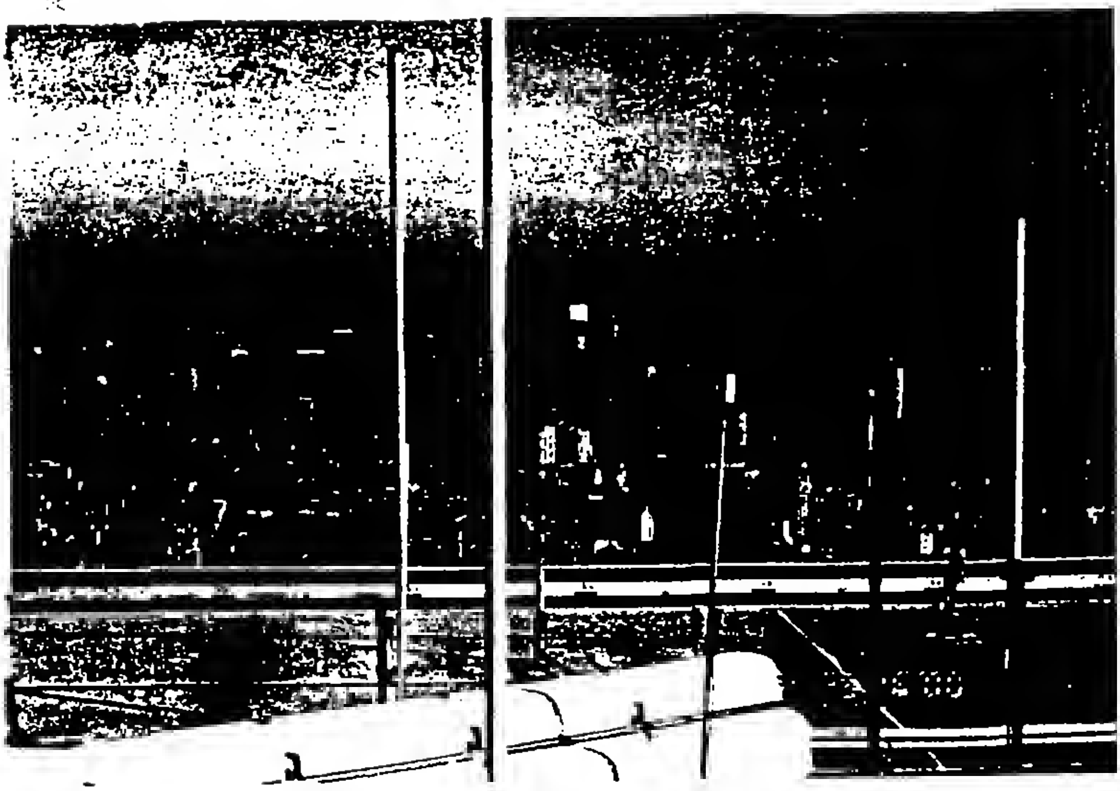


Photo #3: Roof – One World Trade Center.

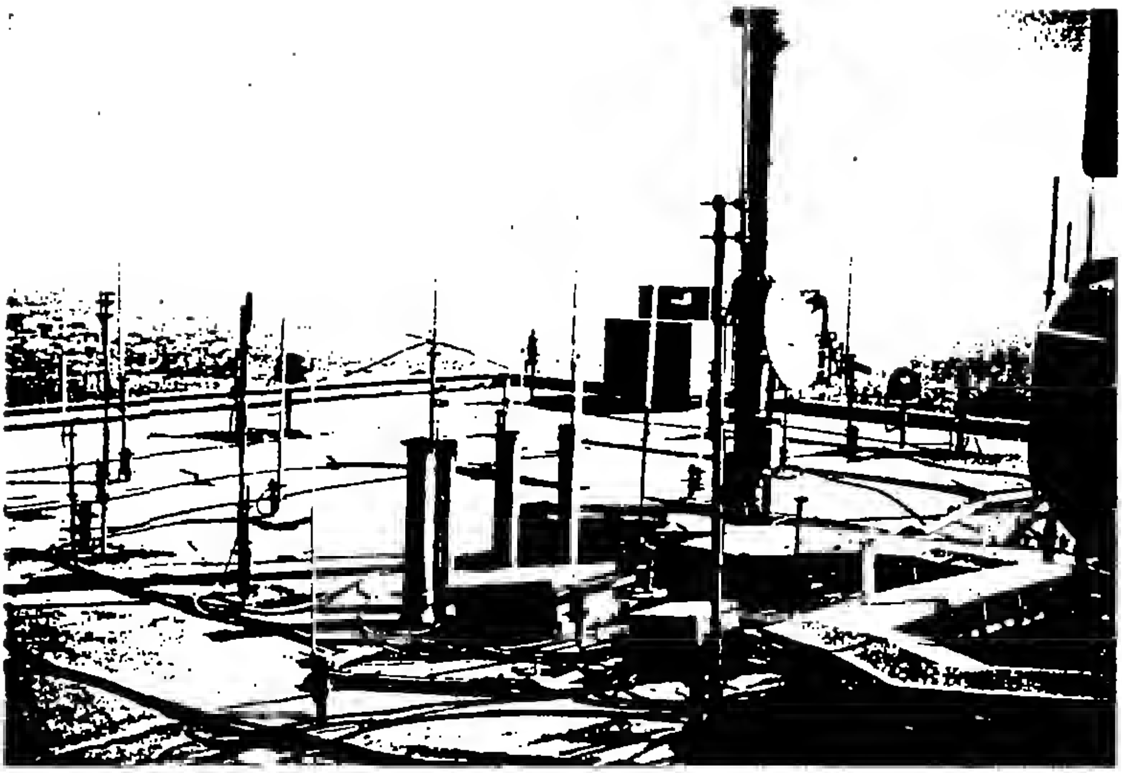


Photo #4: Roof - One World Trade Center.

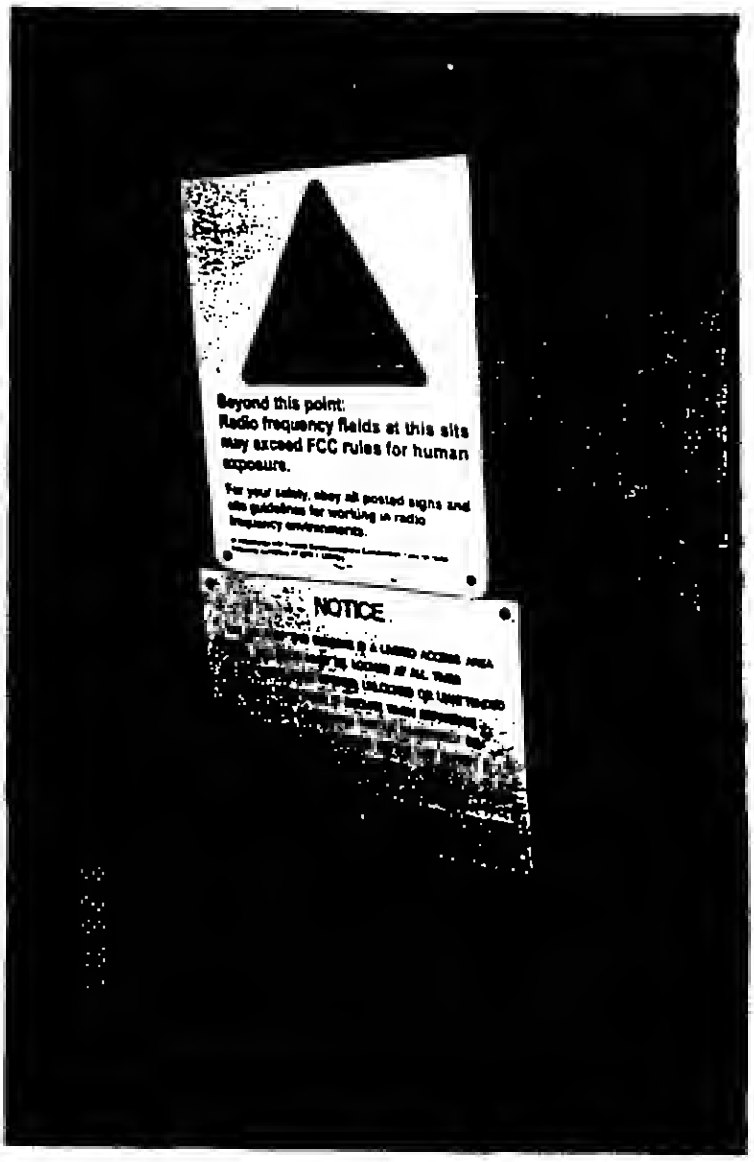


Photo #5: Signage at door to roof - One World Trade Center.

ATTACHMENT 9

Heitmann & Associate Curtain Wall Evaluation

HEITMANN & ASSOCIATES, INC.
BUILDING ENCLOSURE CONSULTANTS
HONG KONG • NEW YORK • ST LOUIS

EXECUTIVE SUMMARY

One World Trade Center

New York, New York

Curtain Wall Evaluation
6 November 2000

The results of our on-site evaluation of the current condition of the curtain wall system on the One World Trade Center project is summarized as follows.

Having been regularly maintained and inspected the general condition of the curtain wall on the tower is relatively good. The curtain wall system appears to be structurally sound and generally air and water tight. The main issues of concern relate to the external appearance of the curtain wall and the ongoing maintenance program that is currently in place.

The original finish on the curtain walls is a clear or natural anodize with a clear lacquer top coat. Over the years the top coat has begun to peel causing a blotchy appearance and the anodized finish has stained and discolored at different rates resulting in a patchwork appearance. One option for improving the appearance of the tower is to repaint the aluminum surfaces of the curtain wall in the field. While minor areas of deterioration of the aluminum has been reported, the primary need for refinishing is to improve the appearance of the tower.

The maintenance program is designed to address issues of water leakage, sealant deterioration, gasket deterioration, component deterioration/failure and any other issues noted during the inspection process. Each tower elevation is inspected every four to five years in accordance with the Local Law requirements. Areas of water leakage appear to be minimal and randomly located, indicating no consistent or typical problem. Sealant and gasket deterioration are dealt with on an "as needed" basis. The issue of component deterioration/failure primarily relates to problems with the operation of the automated window washing system that has resulted in deterioration/failure of the fasteners that fix the window washing platform guide track to the curtain wall system. Recent inspection reports indicate that modifications made to the window washing system appear to have alleviated the problems.

Given the age of the sealants and gaskets it is likely that spot replacement/repairs will continue to be necessary until ultimately all the areas have been replaced or repaired. Thus,

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it would be appropriate to consider addressing all sealant and gasket issues in one comprehensive remedial program covering all of the tower. This would be a major undertaking on a project of this size. Once it is proven that the modifications to the window washing system have been affective in eliminating the damage to the track fasteners, any remaining repairs to the track or its fasteners could also be incorporated into the comprehensive remedial program.

Our full report will address these issues in greater detail.

Respectfully submitted,
HEITMANN & ASSOCIATES, INC.

William G. Young

William G. Young
Manager, East Coast Office

Project :	**One World Trade Center** New York, New York
Project Number:	20063.00
Observation Dates:	Various dates between September 13, 2000 and October 25, 2000
Report Prepared By:	William G. Young

Heitmann & Associates, Inc. has performed an on-site evaluation of the current condition of the curtain wall system at the One World Trade Center project. Our evaluation has included the review of the original project construction drawings (as provided on CD ROM.), review of the mock-up shop drawings for the curtain wall system, review of curtain wall inspection reports provided by the Port Authority of New York and New Jersey, interviews with the Building Engineers and visual inspections. The visual inspections were made from the street/plaza level using binoculars, the main roof, setbacks (at levels 7, 41, 75 and 108), and random interior locations of both finished and unfinished spaces. No drops were made using the building's exterior maintenance platform. Our comments and observations noted during the evaluation are summarized as follows.

(Note: All photographs are provided to indicate/clarify typical conditions and may depict conditions from either One or Two World Trade Center.)

I. <u>General Project Description</u>

A. The project Architect was Minoru Yamasaki & Associates with Emery Roth & Sons P. C. of New York City. The construction of the project was completed in approximately 1975. The curtain wall system was designed and installed by Cupples Products of St. Louis, Missouri. Cupples Products is still in operation under a new organization.

B. The curtain wall system consists of vertical strip windows set between tightly spaced aluminum clad building columns (Refer to photographs 1, 2 and 3). Within the vertical strip windows, aluminum spandrel panels occur at each floor line. Aluminum panels are used to clad the four chamfered corners of the tower and the sloped parapet of the main roof (Refer to photograph 3). The finish on the curtain wall framing, aluminum column cladding, corner panels and parapet panels is a clear or natural anodize. The finish on the spandrel panels is darker and could be a light bronze anodized finish.

C. The vision glass is 1/4" thick with a light grey or bronze body tint. The glass is secured/sealed to the framing with neoprene glazing gaskets at both the interior and exterior side.

D. At the typical floors the interior side of the building columns are finished with vermiculite plaster fireproofing with a plaster finish coat. At the mechanical floors (levels 7/8, 41/42, 75/76 and 108/109) the vision glass and spandrel panels are deleted to allow air flow to and from the louvers set behind the line of the curtain wall. The building columns are fully clad in aluminum at these locations (Refer to photograph 4). The gap between the curtain wall and building structure is sealed with an aluminum parapet cap at the bottom and aluminum soffit panels at the top. The concrete walking surface between the curtain wall and the louvers is waterproofed. Additional decorative trim is added to the face of the column cladding to provide added depth to the system (Refer to photograph 2).

E. The sloped parapet panels at the top of the tower are primarily decorative as the concrete slabs and roofing system below provide the main water barriers (Refer to photograph 5). The parapet panels are supported by steel framing anchored to the building the structure. The steel framing is exposed to the weather.

F. The basic curtain wall design is maintained throughout the height of the tower. The appearance of the curtain wall at the mechanical floor and the top of the tower is modified by changing the width of the column cladding and adding components to increase the depth of the system. The curved elements at the top of the tower are add-on members (appliques) that serve no structural purpose (Refer to photograph 3). The base of the curtain wall provides large expanses of glass by combining three typical building columns into one (Refer to photograph 6).

G. The glass panels are cleaned by a robotic washer that is lowered from a roof car (Refer to photograph 7). The robotic washer is guided by stainless steel tracks set into a recess on the face of the column cladding. The roof car can access the full perimeter of the tower via a system of rails and turntables mounted on the roof. The roof car also incorporates a maintenance platform for retrieving the robotic washer should it become inoperative. The maintenance platform is also used to inspect and maintain the curtain wall system.

II. Document Review

A. Curtain Wall Shop Drawings for the Mock-up

1. The curtain wall is a stick built system that incorporates an overlapping section between the bottom of the spandrel panel and the top of the vision glass at each typical floor level (Refer to detail on sheet SK-1). Similar to a modern stack joint, the overlap section serves as a back up gutter for the system and provides a location to accommodate thermal movement of the curtain wall and building structural deflections. The overlap section extends through the column cladding panels at the same location. It appears that the vision glass pockets are weeped (drained) through the open joint at the bottom of the spandrel panel (i.e., the overlap section). Flashing like

deflectors are provided at the top of the overlap section to direct water draining down the inside of the curtain wall or the face of the building structure into the overlap and out the open joint.

2. The aluminum spandrel panels are captured within a glazing pocket on three sides (i.e., the top and both vertical edges) (Refer to detail on sheet SK-2). The bottom edge is left open for drainage of the overlap. The drawings appear to indicate that the spandrel panel is prevented from slipping downward only by the friction of the glazing gaskets at the three captured edges.

B. Inspection Reports

1. In compliance with Local Laws 10 and 11, the Port Authority of New York and New Jersey maintains a program of regular inspections for the curtain wall system. The inspection and repair procedures which appear to be very thorough were developed by Leslie E. Robertson Associates, R.L.L.P (LERA) Consulting Structural Engineers. Leslie E. Robertson was one of the original structural engineers for the project. The inspections are performed by staff of ABM, the building maintenance contractor, in conjunction with a LERA engineer. The inspection program concentrates on one elevation of the tower each year. Thus, in order to fulfill the requirement to inspect the entire building once every five years the inspections are virtually a continuous process. Presently, the physical inspections do not include the panels at the chamfered corners of the tower as these areas are not accessible with the existing work platform. The Port Authority has recently had a special platform designed and constructed for inspecting and maintaining the tower corner panels. The installation and testing of the new platform are scheduled to be completed by the end of this year. Once the new platform is commissioned, physical inspections of the tower corner panels will begin next year. The main issues currently being addressed by the inspections are summarized as follows.

a. Condition of sealant joints.

(1) Failed sealants are marked for replacement.

b. Damaged column cladding.

(1) Holes and dents in the column cladding are marked for repair. The reports that we reviewed did not indicate the specific cause for the dents or holes in the column cladding. While it is indicated that the holes may be a result of corrosion, there is no indication as to what may have caused the corrosion. A likely cause would be a dissimilar metal in contact with the

aluminum. Based on the inspection reports these conditions appear to be very isolated.

c. Guide tracks for the robotic window washer.

(1) The guide tracks are checked for a variety of conditions including; damage to the track, misalignment between track sections, elongated fastener holes in the track, and loose, damaged or missing fasteners. See additional comments in paragraph II.B.3. below.

d. Spandrel panel position/attachment.

(1) As noted above, it appears that the original design relied on friction to secure the spandrel panel in the correct position. The LERA reports mention lower corner support castings and fixing screws for securing the spandrel panel to the jamb frame. Neither the support castings nor the fixing screws are shown on the shop drawings that we have reviewed. The shop drawings do show castings at the bottom corners of each spandrel panel that are used to cap the jamb extrusions and provide alignment with the jamb extrusions above. There is no indication that the castings are intended to support the spandrel panel. It is possible that the design was changed following the mock-up test. However, without reviewing the project shop drawings it is not possible to determine if the design was changed. Regardless of the design intent, we agree that LERA's remedial recommendation to add a screw to fix the spandrel panel to the jamb extrusion is correct.

e. Attachment of column cladding projections and appliques.

(1) The column cladding projections and appliques are checked for loose/missing fasteners and loose/missing splice plates and connection plates.

2. The conditions noted above are generally repaired on a spot basis following each inspection depending on how critical a situation is relative to safety or performance of the curtain wall system. Thus, issues relating to aesthetic concerns may not be repaired immediately.

3. As the inspections and repair work have progressed over the years, the number of issues needing attention has generally been on the decline. The most significant issue has been related to guide tracks for the robotic window washer. Initially the operation of the robotic window washer was damaging

the guide tracks and the fasteners that attached them to the column cladding. Improvements developed by LERA for the guide system on the robotic wind washer appear to have significantly reduced or eliminated the damage being caused to the guide track and its fasteners. However, there are still repairs to be made to areas of previous damage.

III. Interviews

A. Discussions with Port Authority of New York and New Jersey personnel as facility managers for some of the main tenants indicated that isolated cases of water leakage had occurred in the past and had been repaired. There were no complaints of ongoing water leakage through the curtain wall system. Based on the locations indicated it is likely that at least some of the previous water leakage came through the roofing/waterproofing at the mechanical level setbacks.

IV. Inspections

A. Interior inspections.

1. Random areas of the curtain wall were inspected from the interior of the tower to check for signs of water leakage or other indications of deterioration. Areas were inspected based on accessibility and included both finished and unfinished spaces. Floors 22, 24, 32 and 81 were made available for interior inspections. Our observations are summarized as follows.

a. No signs of water leakage were noted at any of the finished spaces. At some of the unfinished/unoccupied spaces there was staining and efflorescence noted on the plaster finish at the interior side of the column enclosures (between the vision panels) (Refer to photograph 8). These stains could be the results of water leakage through the curtain wall or condensation that formed on the interior surface. It was reported by Port Authority personnel that during certain conditions condensation did form on the inside surface of the curtain wall. This condition is possible as the curtain wall shop drawings that we have reviewed do not indicate any significant amount of thermal insulation within the system.

b. As the plaster finish at the interior side of the column enclosures (between the vision panels) is supported by the curtain wall framing it (the plaster) is subjected to the same deflections that occur in the curtain wall system. These deflections have resulted in horizontal cracks in the plaster finish coat (Refer to photograph 9). While the curtain wall framing is typically designed to limit deflections to 1/175 of the span between supports, members supporting a more rigid material like plaster would be designed to limit deflection to 1/360 of

the span or less. At this time cracks appear to be primarily an aesthetic problem that is addressed with spackle and paint when the floors are renovated.

c. A number of locations were noted where the interior glazing gasket had dropped out of its pocket at either the top or side of the vision glass panel. This condition is a result of the glazing gasket having taken a compressive set and lost some of its flexibility. Additionally, the original design may not have had sufficient engagement between the glazing gasket and the window frame. Thus, under a negative wind load the glass is pressed against the outer gasket, compressing it and opening up the gasket pocket on the interior allowing the gasket to drop out. LERA has proposed replacing the gaskets that have dropped out with new gaskets. As the primary function of the interior gasket is to provide a separator between the glass and metal frame, the existing gaskets could be reinstalled using a few small beads of silicone sealant to the gasket in place.

B. Exterior Inspections.

1. The exterior visual inspections were made from the street/plaza level using binoculars, the main roof and setbacks (at levels 7, 41, 75 and 108). Our observations are summarized as follows.

a. In general the curtain wall system appears to be in good structural condition with no obvious signs of failure.

b. The condition of sealant joints visible at the setbacks varied from poor (sealant is dry and hard) to recently replaced (Refer to photograph 10). Replacement of sealants appears to have been done on a spot basis to address specific areas of failure or reports of water leakage. Additionally, joints that were intended in the original design to be left open have been sealed. The open joints are intended as a drainage path for water that enters the curtain wall system in the floor height above. If the system is functioning as designed, water should not be able to enter the open joints and reach the interior of the tower. However, if failure of internal seals or flashings prevents the system from functioning as designed, it may be necessary to seal the open joints to prevent water entry instead of dismantling the system. When sealing the open joints, caution must be exercised to prevent water being trapped within the curtain wall system.

c. The main issue from the exterior is the overall appearance of the tower. Over time the anodized finish on the column cladding, spandrel panels, corner panels, and sloped parapet panels has deteriorated resulting in a patchwork appearance (Refer to photographs 2 and 3). The discoloration is caused by dirt and chemicals in the atmosphere that embed themselves in the porous surface of the aluminum or cause the aluminum to corrode. Additionally, it appears that the anodized finish of the curtain wall, particularly the spandrel panels, was coated with clear lacquer that is now peeling off (Refer to photographs 11 and 12). The areas where the clear lacquer coating has peeled away are very visible from the street/plaza level. It has been indicated by the Port Authority that the curtain wall system was originally supplied with the clear lacquer coating applied over the anodized finish.

d. From the roof level it was noted that the steel framing that supports the sloped parapet panels is lightly rusted (Refer to photographs 13 and 14). The base of the steel framing is supported on a pedestal that comes up from the building structure below. Steel shim plates used between the steel framing the pedestal to adjust the level are severely rusted (Refer to photograph 15).

V. Summary

A. Based on our onsite observations and evaluation of the documents, the overall condition of the curtain wall system is generally good. While there are ongoing maintenance issues to be addressed, there do not appear to be any significant structural or waterproofing issues that require attention. Nothing in our observations or evaluations leads us to believe that the condition of the curtain wall will deteriorate significantly in the foreseeable future.

B. The ongoing inspections will need to be continued in some form to fulfil the requirements of the Local Laws. Inspection of the guide tracks for the robotic window washer would likely need to be a high priority until such time that the modifications to the guide system are proven to be affective in eliminating damage to the guide tracks and fasteners.

C. The ongoing maintenance work represents a significant capital outlay each year. The maintenance program could be converted to a remedial program whereby repairs for the known problems are applied to the entire tower, bringing the whole of the curtain wall system up to an equal state of repair. This would mean replacing or modifying components before they actually fail. Given the size of the project, a remedial program of this type would be a substantial undertaking. While this approach would have an extremely high up front cost, it should significantly reduce the cost of and need for ongoing maintenance.

D. Our recommendations regarding the issues noted during our inspections are summarized as follows.

1. Water leakage - As there does not appear to be any significant or typical water leakage problems, we recommend that water leaks continue to be addressed as they are reported. A remedial program that addresses sealant repair and replacement for the entire tower would reduce the potential for future water leakage.

2. Cracked plaster - As the cracks present primarily an aesthetic concern, we do not feel that any specific action is required relating to this issue. The cracks can continue to be addressed as floors are renovated. Should a permanent solution be desired it may be possible to replace or clad over the plaster with drywall or other more flexible material.

3. Interior gaskets - The dropping out of the interior glazing gaskets is a minor issue and can be corrected by reinstalling the existing gasket into the glazing pocket with a few small beads of silicone sealant.

4. Sealant joints - While the overall condition of the sealants is poor due to its age and type, actual failures are isolated. Thus, the sealant could continue to be addressed on an "as needed" basis or all sealants could be replaced as part of an overall remedial program.

5. Aluminum finish - While removal of the deteriorated clear lacquer coat would eliminate the blotches and improve the appearance of the tower, it is likely that the patch work appearance would remain due to differences in the shade of the finish on adjacent components. It is our opinion that cleaning the aluminum finish would not significantly reduce the patch work appearance. An option for improving the overall appearance would be to paint the aluminum components in place on the tower. While this process would be a major undertaking on a project of this size, it has been successfully done on large projects. As this is an aesthetic issue there is no need to do anything with the aluminum finish should the current appearance be accepted. If painting is to be considered, it should be integrated with a program to replace the existing exterior seals within the curtain wall system at the same time.

6. Rusted steel framing - While the rusting of the steel framing for the sloped parapet panels is mild at this point, we recommend that the steel framing be cleaned, primed and painted to prevent further deterioration. The rusting of the steel shims is more severe and should also be addressed. The mild steel shims should be replaced with galvanized or stainless steel shims and the pedestals cleaned, primed and painted.

While our inspections and evaluations have covered a random sampling of conditions, we believe that our findings are representative of the entire curtain wall system. Should any additional information or clarification be required, please feel free to contact our office.

Respectfully submitted,
HEITMANN & ASSOCIATES, INC.

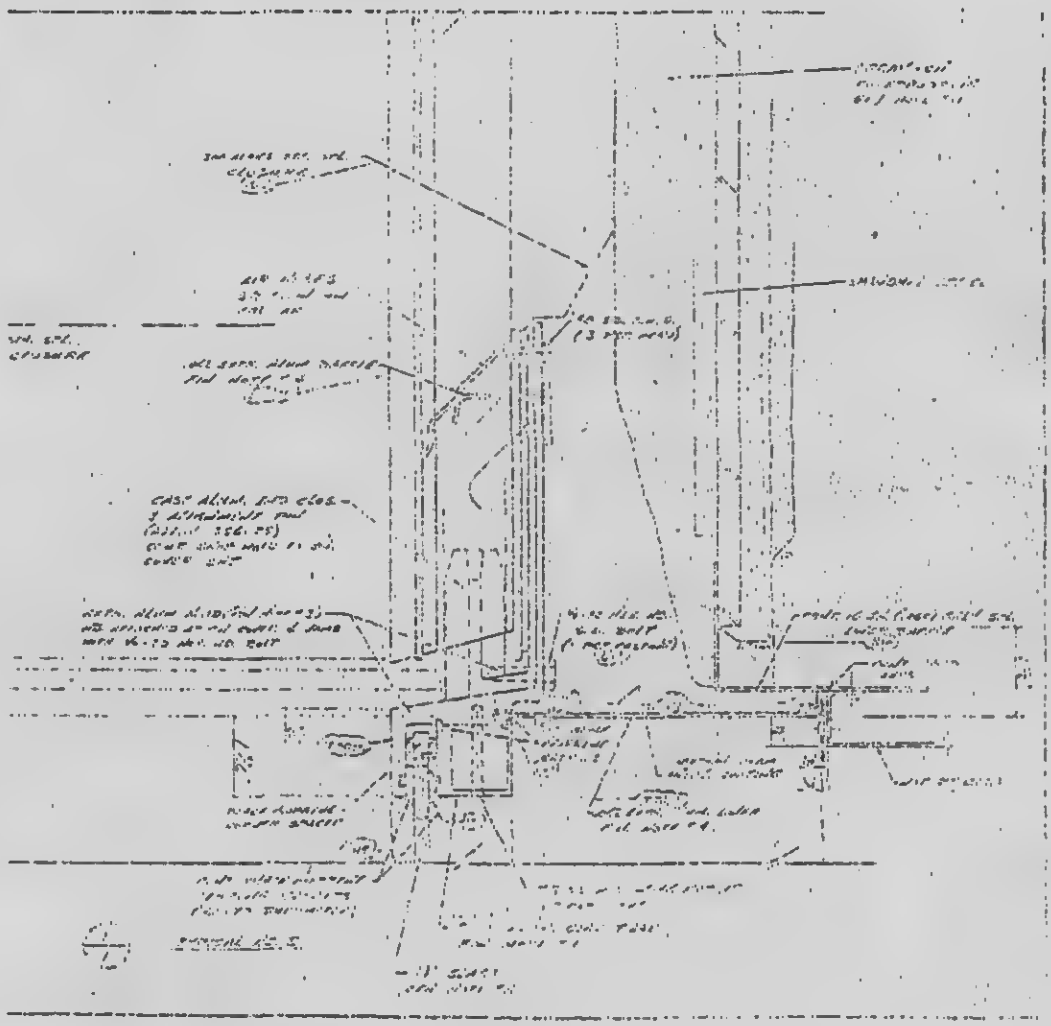
William G. Young

William G. Young
Manager, East Coast Office

Attachments

One & Two World Trade Center

(HAI Project #20063.00)



One & Two World Trade Center

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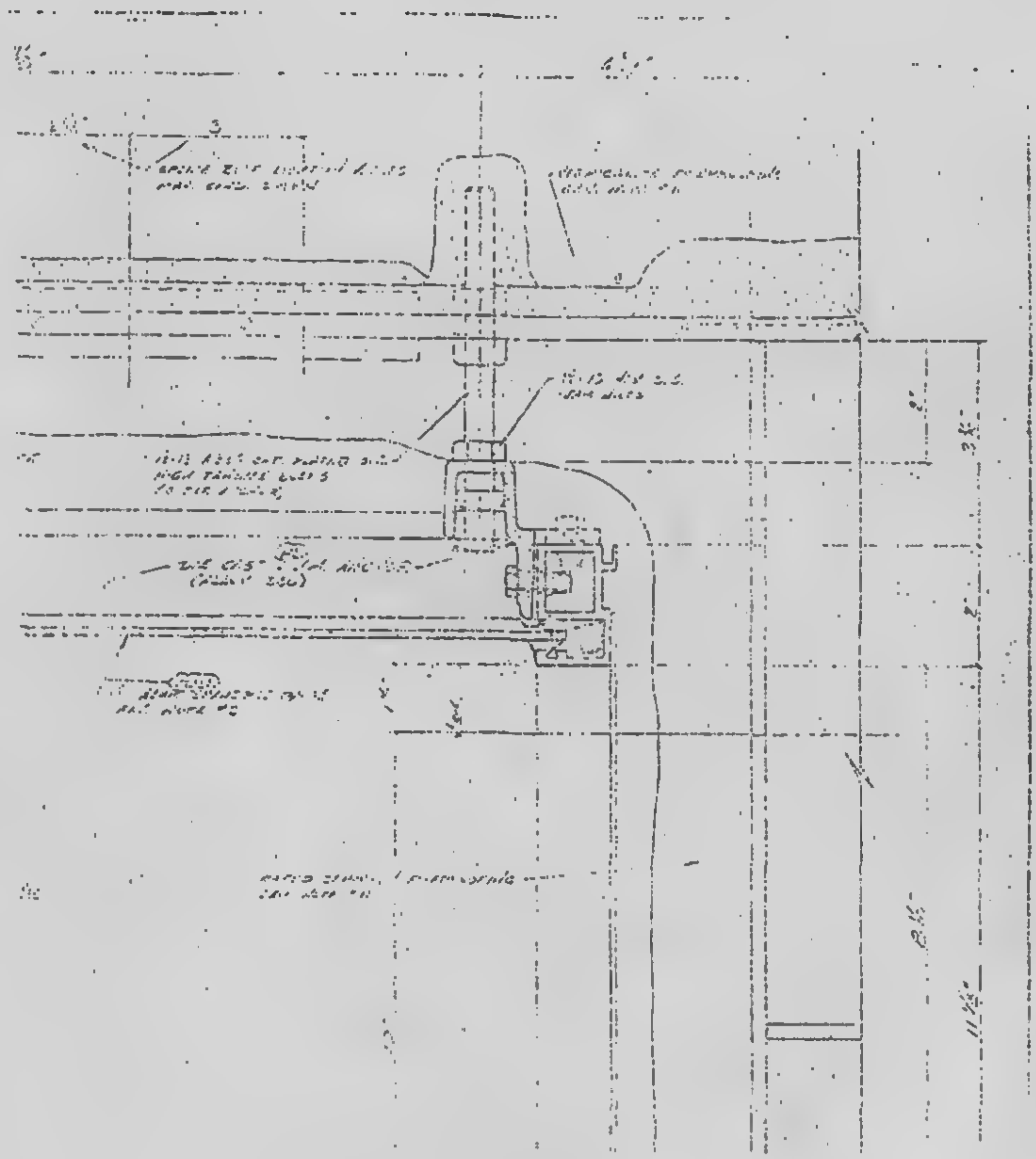

One & Two World Trade Center

(HAI Project #20063.00)

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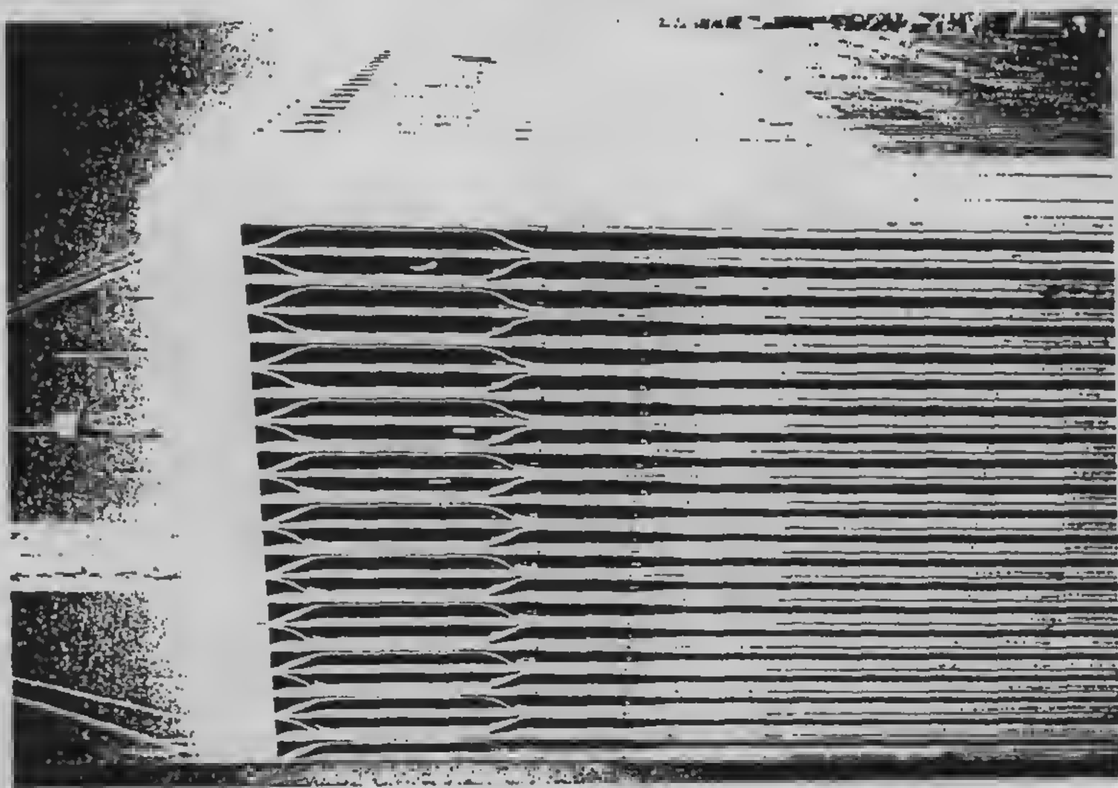
One & Two World Trade Center
(HAI Project #20063.00)



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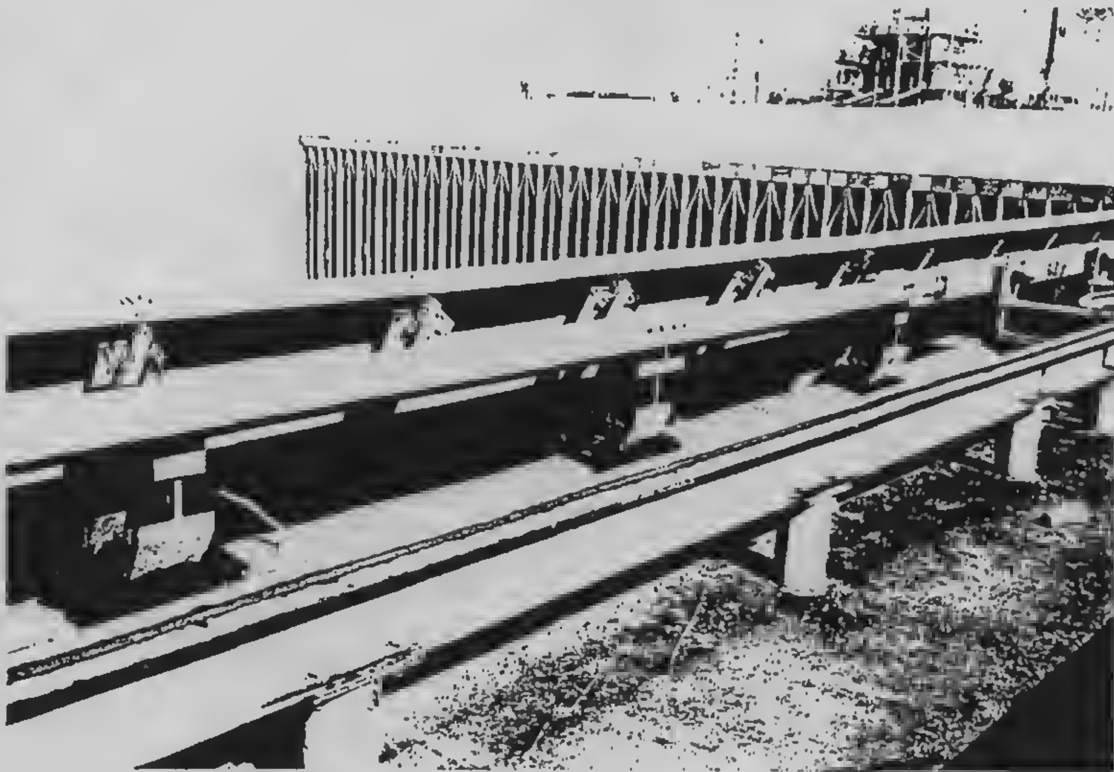

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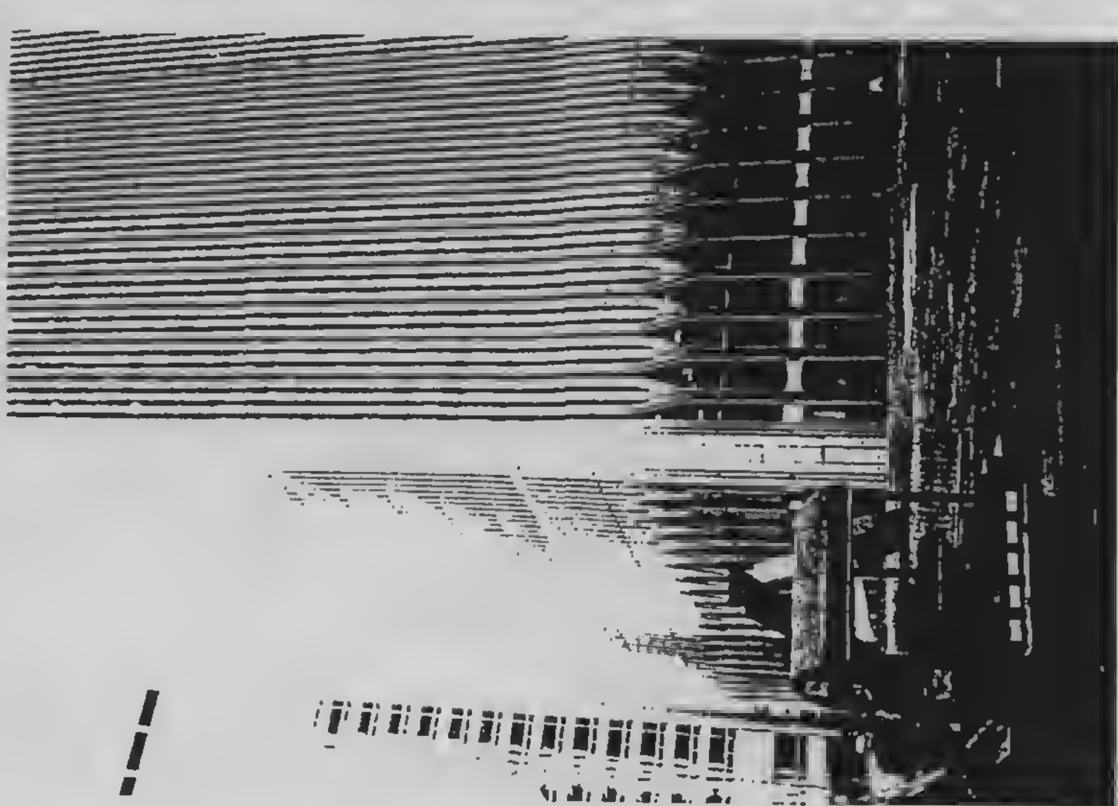

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One & Two World Trade Center
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